THE

AMERICAN GEOLOGIST

A MONTHLY JOURNAL OF GEOLOGY

AND

ALLIED SCIENCES.

VOLUME XIV.

JULY TO DECEMBER, 1894.

MINNEAPOLIS, MINN.

THE GEOLOGICAL PUBLISHING COMPANY.

1894.

ALFRED ROPER PRINTING CO., Printers.

CONTENTS.

JULY NUMBER.

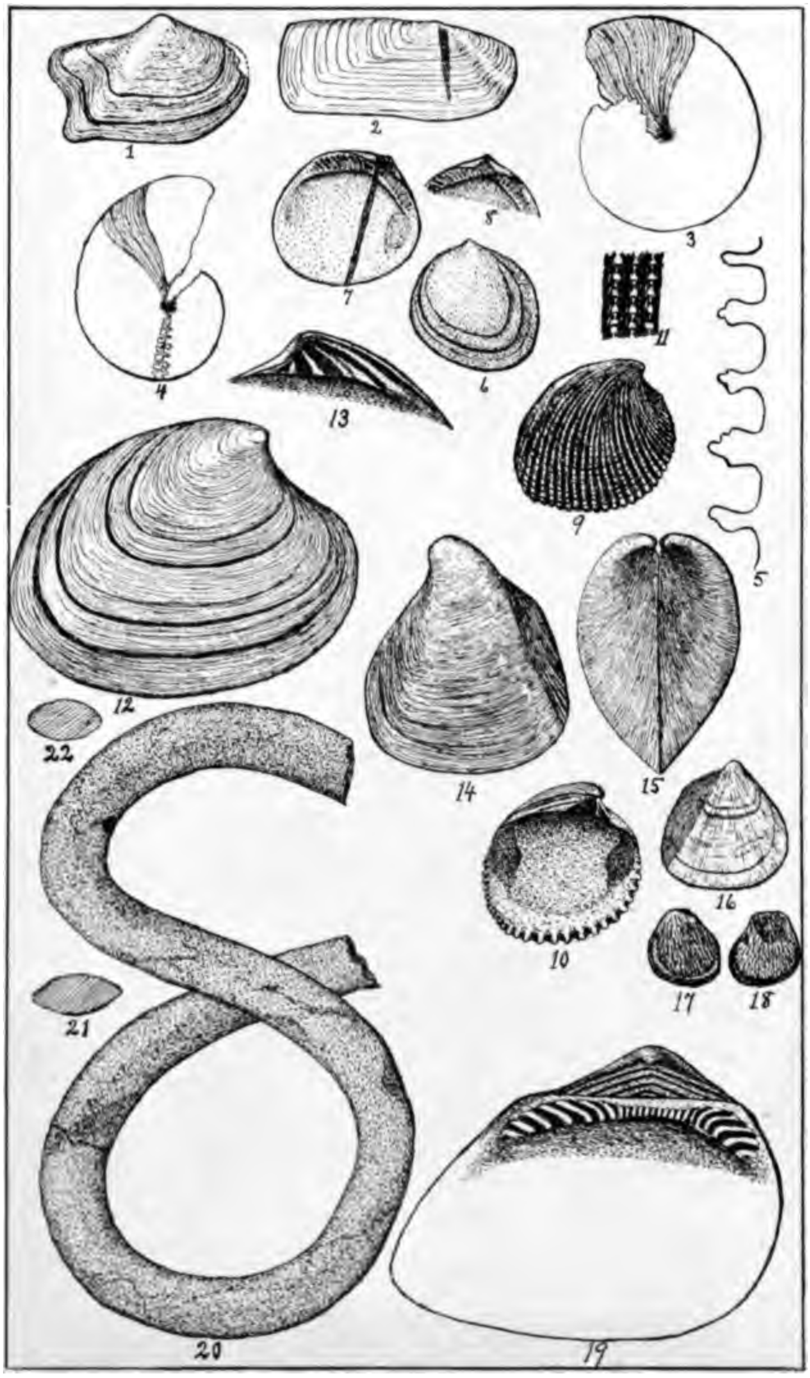
AUGUST NUMBER.

SEPTEMBER NUMBER.

OCTOBER NUMBER.

NOVEMBER NUMBER.

DECEMBER NUMBER.



New and little-known Invertebrata from the Neocomian of Kansas.

THE

AMERICAN GEOLOGIST

VOL. XIV. JULY, 1894. No. 1.

NEW AND LITTLE-KNOWN INVERTEBRATA FROM THE NEOCOMIAN OF KANSAS.*

By F. W. CRAGIN, Colorado Springs, Colo.

The Invertebrata herein treated were collected by the writer in Kiowa and Clark counties, Kansas.

The "Belvidere section" referred to below, is that shown in the exposures on the south side of the Medicine Lodge river, in the southeastern part of Kiowa county, at Belvidere. It was first described in January, 1889, in the *Bulletin of the Washburn College Laboratory of Natural History* (No. 9, pp. 35, 36). It was more fully described in my article "On the Cheyenne Sandstone and the Neocomian Shales of Kansas," which was published in No. 11 of the same *Bulletin* (see pp. 75-79), and, with some revision, in Vols. 6 and 7 of THE AMERICAN GEOLOGIST. (See Vol. 7, pp. 25 and 26.)

The "Bluff Creek section," described also in the article "On the Cheyenne Sandstone and the Neocomian Shales," etc., is in Clark county on the east bluff of Bluff creek, about two miles below the old Vanhem postoffice.

(? NEREIS) INCOGNITA, sp. nov.

Plate I, figs. 20-22.

The specific name, *incognita*, is proposed as a convenient designation for the large, apparently nereid, worm that inhabited the sandy beach of the Comanchean sea of southern Kansas, and the casts of whose burrows (part of one of which is shown natural size from above and in cross-section in figures 21 and 22 of Plate I) occur commonly in Kiowa county in No. 5 of my Belvidere section, and occasionally, at least, in Clark county, in the earthy or saccharoidal sandstone which constitutes No. 4 of my Bluff Creek section.

*Advance sheets distributed May 30, 1894.

The burrows form boldly sweeping, tortuous curves which lie in a slightly warped surface and occasionally cross themselves in a sigmoid or "figure 8" path. The transverse section of the cast is lenticular, averaging about 10 and 6 mm. in major and minor diameters.

PLICATULA SENESCENS. sp. nov.

Plate I. figs. 17 and 18.

Shell quite small, compressed, inequivalve, obliquely subpyriform or inequilaterally rounded-triangular; beaks depressed and indistinct, that of the right valve subtruncate by the scar of adnation; valves ornamented with numerous punctations and short, radially disposed, punctiform wrinkles, so arranged that the intervening elevations do not constitute distinct, continuous, radial, rib-like plicules such as are seen in most species of this genus, but, rather, faintly suggest them; margins of valves thickened, that of the left valve forming a broad, distinctly elevated, concentrically laminated border in marked contrast with the discal sculpture; right valve moderately convex, the left flattish or slightly concave.

Measurements.—Hight 11; length 10; breadth 4.5 mm.

Occurrence.—In No. 3 of the Belvidere section, southwest of the railway station. I have seen but two or three specimens.

AVICULA BELVIDERENSIS, sp. nov.

Shell strongly inequivalve, smooth, obliquely purse-shaped, larger than that of *A. subgibbosa* M. & H., as figured in Meek's Cretaceous Invertebrata (Plate 28, fig. 12), to which it bears considerable general resemblance, differing from it apparently in having a longer hinge-line, a relatively larger and more prominent anterior and larger posterior ear; anterior ear abruptly compressed, marked off by a distinct but shallow sulcus, and marked with one or two infero-marginal folds; posterior ear continuous with the gently concave posterior slope of the shell; left valve strongly and rather narrowly arched from front to rear, much more convex than the right, its beak also more elevated above the hinge-line than that of the latter (? hinge-line as long as or longer than the shell).

Occurrence.—I have before me thirteen specimens of this species from No. 5 and one from No. 3 of the Belvidere section, taken in the south and southwest vicinity of Belvidere. All are imperfect, none showing complete outlines or the exact form of the posterior ear; and none allowing precise measurements.

PINNA COMANCHEANA, sp. nov.

Shell large, thin; anteriorly inflated and subcircular in cross-section, becoming more compressed and with exteriorly concave upper slopes posteriorly; not, or only very obtusely, angulated along the median line; increase of hight with distance from beak more rapid than in *P. lakesii* White; decussately ornamented with rather remote radial costellæ and somewhat less conspicuously raised remote concentric lines, there being about nine of the radial costellæ on the concave slope.

The shell attains a length of at least eight or nine inches.

Occurrence.—Common in rocks of the Fredericksburg division in Kansas, Texas and New Mexico; especially in the Comanche Peak limestone of Texas. The largest specimen that I have observed is in the collection made in the Tucumcari district of New Mexico by the W. F. Cummins' party of the Geological Survey of Texas. The types are specimens in the writer's private collection from Kansas and Texas and in the Colorado College collections from southwestern Kansas. All of the specimens thus far obtained near Belvidere, Kansas, are from No. 5 of the Belvidere section.

CUCULLÆA (IDONEARCA) TERMINALIS, var. nov. recedens.

Plate I, fig. 19.

The hinge of *Cucullæa terminalis* Con. being entirely unknown, I present a figure of the interior of the Belvidere, Kansas, *Idonearca* which I provisionally referred to *C. terminalis* in my "Contribution to the Invertebrate Paleontology of the Texas Cretaceous" (Fourth Ann. Rep. Geol. Surv. of Texas, p. 175). This shell occurs in great abundance in No. 5 and occasionally in No. 3 of the Belvidere section; and is found through the entire thickness of the Comanche shales of Clark county.

As compared with the type-figure of *C. terminalis*, the Belvidere species has the beaks less anterior, and by no means terminal, though their position is somewhat variable and the figure now given represents perhaps a little more than the average of their recession from a terminal position.

Typical *C. terminalis* belongs to the Alternating beds, while the *C. recedens* belongs to the lower part of the Fredericksburg division, as represented in Kansas and as seen on a hill-slope a little west of Weatherford, Texas (where occurs a shell-bed that is apparently the equivalent of No. 5 of

my Belvidere section in paleontologic character and stratigraphic position). It is therefore possible that *recedens* may prove to be a species distinct from *terminalis*, when future explorations in the Alternating beds shall lead to the discovery of the hinge of undoubted *terminalis*.

LIMOPSIS SUBIMBRICATUS, sp. nov.

Plate I. figs. 6—8.

Shell small, obliquely subrotund, or obliquely rotund-quadrilateral, of moderate convexity; beaks placed a little in advance of the middle, small but distinct, giving the dorsal outline of the shell an apiculate aspect; hinge-plate ample, but gradually narrowed to a strait in the mid-part where its lower border is gently subangulated at a point a little back of that immediately below the beaks; denticles about twenty-three in number, arranged in a divaricate series, median and terminal denticles short and minute, the intermediate larger and elongate denticles for the most part curved or angulated; outer surface of shell smooth, except usually for a few remote, unevenly distributed, coarse, concentric growth-lines, or incipient imbrications; margin entire.

Measurements.—Hight 19; length 19; breadth 10 mm.

Occurrence.—Common in No. 5 of the Belvidere section, south of the railway station.

NUCULA CATHERINA, sp. nov.

Shell small, compressed, triangular, or cuneate-ovate; the entire exterior ornamented with numerous concentric rows of small, closely set, compressed, hyphen-like tubercles, with one or two distal, broad, deeply-impressd, concentric growth-lines, and with delicate radial striæ; each tubercle set so that its trend agrees with the direction of the subjacent concentric growth-line, and all of the tubercles being arranged not only in concentric series but at the same time in quincunx order, so as to form two sets of intersecting, oblique, and gently curving rows.

Measurements.—Hight 10.5; length 15; breadth 5 mm., in a small specimen. An imperfect larger specimen indicates dimensions at least one and a half times these.

Occurrence.—In No. 3 and in the transition from No. 4 to No. 3 of the Belvidere section, one and a half to two miles southwest of the Belvidere railway station.

None of the three type-specimens show the hinge charac-

ters; so that the generic position must, for the present, remain somewhat doubtful, the provisional generic reference being based upon the shape and general aspect. The species, however, is so strongly marked by its exquisite ornamentation that it cannot be mistaken for any other with which I am acquainted. It is named in honor of my wife.

REMONDIA FERRISSI Cragin.

Plate I, fig. 1.

The illustration is from a drawing of the type-specimen made in 1889, when the original description of the species (published in Bull. Washb. Coll. Lab. Nat. Hist., Vol. 2, No. 10, Dec. 1889, p. 68) was prepared.

Attention may here be called to some errors which crept into that description. In the fourth line of the description, the ratio, "3:7," should read 7:3. In the fifth and tenth lines, the word, "convex," should read, concave.

The type was from No. 3 of the Belvidere section; but the writer has recently collected several other examples in No. 5, south of the Belvidere railway station. These agree well in size and outline with the type, and show that the latter was an adult specimen, and that the species is quite distinct from the Sonoran *R. furcata* Gabb. But some of them present an ornamental feature not observed in the type, in having a series of several parallel, oblique folds, trending backward and a little upward on the umbonal region. The crests of these folds are acute, though low, and the troughs are broad and shallow.

CARDITA BELVIDERENSIS, sp. nov.

Plate I, figs. 9-11.

Shell of small to medium size, triangular or cardiform, moderately to rather strongly ventricose; beaks placed near the anterior side and directed strongly forward; exterior of either valve ornamented with about 26 ribs, of which 19 or 20 are narrow, prominent, spinigerous, and separated by valleys about twice as wide as themselves, the other 6 or thereabout being low, plainer, and crowded; spines of the larger ribs much more closely set than the ribs themselves, short, erect, subtruncate (commonly appearing as little more than coarse granules owing to the weathering of the shell); margin of valves deeply notched.

Measurements.—Hight 28; length 27; breadth 17.5 mm., in the largest specimen; average specimens having about two-thirds of these dimensions.

Occurrence.—The species abounds immediately south and southwest of Belvidere, in the shell-platform designated as No. 5 of my Belvidere section, associated with *Sphenodiscus pedernalis* Roem., *Schloenbachia peruviana* Von B., *Limopsis belviderensis* Crag., *Serpula* sp., etc. It is perhaps the commonest fossil of this horizon, excepting the small or "*hilli*" phase of *Gryphæa pitcheri* Mort. It occurs here, however, mostly in weathered specimens that show the short spines as more or less protuberant granules only. It occurs sparingly in No. 3, sometimes with the spines beautifully preserved. I have collected a few specimens in the lower part of the Bluff Creek Neocomian section in Clark county, Kansas. I have also seen several examples of this species among specimens collected by Mr. W. F. Cummins in the Tucumcari district in New Mexico.

(?CARDIUM) MUDGEI, sp. nov.

Size apparently about that of *Cardita belviderensis*, shell ornamented with heavy, narrowly-interspaced, round-topped, radial ribs, and with numerous freely projecting, concentric, lamellar borders, which are relatively more prominent in crossing the ribs than elsewhere, forming thereupon strong hood-like imbrications. Within a space of 9 millimeters on the ventral margin of the type specimen, there are 5 ribs, and on the largest one of these ribs there are, on the distal 7 millimeters of its length 9 of the hood-like imbrications.

Occurrence.—No. 3 of the Belvidere section, about a mile and a half southwest of the Belvidere railway station.

Only a part of a single valve of this shell has been found, so that the generic place of the species is somewhat doubtful; but the ornamentation is of such a character as to readily distinguish the species, which may belong to *Cardita* or to *Pectunculus*.

The Fox Hills bivalve, *Pectunculus subimbricatus* M. & H., as figured in Meek's Cretaceous Invertebrata, Pl. 28, fig. 14 a, is a shell whose ornamentation recalls, but does not specifically duplicate, that of the present species, its hood-like spines, or imbrications, being less prominent than in the latter and otherwise different.

The species is named after that most excellent pioneer worker in Kansas geology, the late Prof. Benjamin F. Mudge.

CARDIUM (NEMOCARDIUM) BISOLARIS, sp. nov.

Plate I, fig. 16.

Shell small, quadrilaterally or subtriangularly rotund, of moderate convexity; beaks subcentral, slightly in advance of the middle; posterior fourth (or less than fourth) part of

outer surface ornamented with thirty or more, slender, radial costellæ, the anterior three-fourths being devoid of concentric costellæ and marked with extremely delicate and crowded radial striæ; inner part of free margin delicately notched, or crenulated.

The costellæ of the posterior part are not visibly echinate in the types.

Measurements.—Hight 23; length 21; breadth 15 mm.

Occurrence—Moderately common in No. 5 of the Belvidere section, south of the railway station.

ROUDAIRIA QUADRANS, sp. nov.

Plate I, figs. 14 and 15.

Shell small, short, strongly elevated, triangular, the discs of moderate convexity; beaks situated considerably in advance of the middle, elevated, somewhat compressed on the anterior part and strongly so on the posterior, curved inward and downward and directed somewhat forward; no distinctly limited lunule; anterior and discal slopes flattish-convex, separated from each other by a broadly-rounded, scarcely appreciable angulation, their outer surface marked only by ordinary, unequal, concentric growth-lines; posterior slope (about one-fourth of the valve) strongly flattened, separated from the discal slope by an abruptly rounded angulation, and ornamented by numerous linear radial costellæ separated by grooves of about their own width.

Measurements.—Hight 50; length 47; breadth 36 mm., in the largest specimen. Most of the other specimens before me are relatively shorter and some of them much so.

Occurrence.—Southwest of Belvidere, in No. 3 of the Belvidere section; chiefly near the transition from No. 4 to No. 3.

The exact number of radial costellæ is not shown in the types; but in the well-preserved part of the striated area one example shows fifteen and indicates apparently between twenty and thirty for the full number. Two of the type-specimens are much larger than that selected for illustration, and one of these is of a short, elevated form, the other relatively longer, showing that the shell is subject to considerable variation.

TAPES BELVIDERENSIS, sp. nov.

Plate I, figs. 12, 13.

Shell of medium size, ovate, or in elevated specimens triangular, ovate, the superior outline excavated in advance of

the beaks; valves of moderate convexity, rather thin, beaks placed at less than one-third of the length from the anterior extremity, only moderately prominent (their summits rising, in adult specimens, about two millimeters above the cardinal teeth); hinge of moderate size; the three divergent cardinal teeth separated by clefts of subequal amplitude but very deep and abruptly excavated in the case of the anterior cleft and less so in the posterior; anterior cardinal tooth small, second tooth larger and compressed but not sharply so, third large, broad, flattish-topped and feebly channeled or bifid; posterior lateral tooth rather large and long; surface marked with ordinary concentric growth-lines of which a few, not regularly spaced, are usually much stronger than the rest.

Measurements.—Hight 45; length 49; breadth 22 mm., in an elevated example. Fig. 12 shows an example of the more elongate form.

Occurrence.—In No. 3 and 4 of the Belvidere section, south and southwest of the railway station. Most common near the transition from the former to the latter horizon. Specimens in the upper part of 4 frequently occur as casts and moulds, while those in the lower part of 3 are usually well preserved.

None of the rather numerous specimens before me show the pallial line or the teeth of the left valve, but one specimen shows the posterior adductor-scar to be only faintly impressed.

There is considerable variation in the form of this shell. In some examples, the hight is equal to only three-fourths of the length, the outline in such being subovate; in others, the hight becomes fully equal to the length and the outline accordingly is more triangular.

LEPTOSOLEN OTTERENSIS, sp. nov.

Plate I, fig. 2.

Shell compressed, elongated, subrectangular, the hight contained nearly two and a half times in the length; dorsal and ventral margins nearly parallel back of the beaks, and somewhat convergent anteriorly from them; anterior margin rounded, posterior truncate; beaks at about the anterior third of the length; valves thin, each presenting a broad, low, and gently elevated, distally widening fold, which extends from the beak obliquely downward and forward to the antero-ven-

tral margin; cast marked with a strong, distally narrowing and shallowing sulcus which radiates from the beak downward and slightly forward, becoming obsolete before it reaches the ventral margin, and indicating a corresponding rib on the inner face of the valve; surface of cast marked with crowded, fine, concentric, and coarser, rather remote, and evenly distributed growth-lines.

Measurements.—Hight 13; length 32 mm.

Occurrence.—The figure of this species was drawn several years since by the writer, who obtained the type and only known specimen from dark clay shale in the "Blue Cut" of the A. T. & S. F. railway, on Otter creek, a few miles south-southwest of Belvidere. It was associated with *Cyprimeria gradata* Crag., *Cardium kansasense* Mk., *Turritella seriatim-granulata* Roem., *Schloenbachia peruviana* Von B., *Sphenodiscus pedernalis* Roem., and other species belonging chiefly to No. 3 of the Belvidere section.

MACTRA ANTIQUA, sp. nov.

Shell small, triangular, longer than high, of very moderate convexity; upper anterior margin of either valve, in advance of the feebly excavated beak-front, forming nearly a straight line a little shorter than the feebly convex line described by the supero-posterior margin; anteumbonal and postumbonal slopes depressed so as to present a broad and shallow radial sulcus, the anterior sulcus separated from the discal surface by a slight angulation; beaks slightly in advance of the middle, their apices turned inward and but very little forward; hinge narrow; the anterior Λ-shaped cardinal tooth of the left valve short and stout, its sinus shallow; posterior cardinal narrowed above, broad below, the broad lower extremity bearing on its anterior side a short denticle which imperfectly subdivides the cartilage-pit.

Measurements.—Hight 23.5; length 27; breadth 16 mm.

Occurrence. Several specimens from the transition between No. 4 and No. 3 of the Belvidere section: one to two miles southwest of Belvidere station.

The occurrence is interesting, as the genus *Mactra* is chiefly characteristic of recent and Neocene times and is but sparingly represented in the lower Cretaceous, *M. occulta* of the upper Jurassic being the only species of this genus known to occur earlier than the Neocomian.

MARGARITA MARCOUANA, sp. nov.

Shell turbinate, spire moderately prominent; whorls four and a half, convex, increasing rapidly in size, the large body-

whorl obliquely flattened below and above; aperture subcircular, apparently as high as wide; no umbilicus; columella flattened below; whorls marked with prominent, oblique growth-lines, and ornamented with three strong, equidistant, coarsely but regularly beaded carinæ above which, on the body-whorl, is a fourth smaller one close to the suture.

Measurements.—Hight 15; breadth 14.5 mm.; divergence of slopes 85 degrees.

Occurrence.—Two specimens only of this species are known. These were obtained: one in No. 5 of the Belvidere section, three fourths of a mile south of the railway station; the other from No. 3, about a mile and a half southwest of the station.

The species is very closely related to *M. mudgeana* Mk., from which it is distinguished chiefly by the beaded character of the revolving carinæ, a character which also distinguishes it from *Turbo reedi* Kpng. Our specimens are somewhat smaller than the type of *M. mudgeana*, as figured by Meek.

The species is named in honor of Mr. Jules Marcou, discoverer of the American Neocomian.

MARGARITA (SOLARIELLA) NEWBERRYI, sp. nov.

Shell thin, low-turbinate, or spherico-turbinate, consisting of about four rapidly enlarging whorls, spire small and low, the sutures rather deeply impressed, the body-whorl very large and ventricose; surface of each whorl ornamented with coarse, unevenly elevated revolving lines or granuliferous ridges, the intervals between which are marked with usually two similar but much finer revolving lines, the whorls being also obliquely crossed by a system of rather remote, narrow, raised lines which proceed from the apex down the slopes of the shell with a somewhat sigmoid, or sickle-like, curvature and produce more or less distinct eminences at their intersections with the revolving ridges. Of the primary revolving lines or ridges, there are six or seven on the flank and shoulder of the body-whorl.

Measurements.—Hight of shell 13.5; breadth of body-whorl 15 mm.; divergence of slopes 104 degrees.

Occurrence.—The type and only known specimen of this species was found in No. 5 of my Belvidere section, half or three-fourths of a mile south of the railway station, associated with *Gryphæa pitcheri*, var. *hilli*, *Cardita belviderensis*, etc.

The base of the type specimen is imperfect, and does not show the

apertural details nor the ornamentation of the lower part of the body-whorl. The broken surface apparently indicates an open umbilicus, but not so plainly as to banish doubt.

The species was named in honor of the late illustrious Dr. J. S. Newberry: earliest geological explorer of southwestern Kansas.

TROCHUS TEXANUS Roem.

A single well preserved specimen of this rare *Trochus* was obtained about two miles southwest of Belvidere station, from No. 3 of the Belvidere section. This, so far as the writer is aware, is the first reported occurrence of the species outside of the type-locality.

The shell is a little more elevated than the example figured by Dr. Roemer, owing to the less rounded character of the apical part of the spire; and, though the spiral lines of granules are five in number on each whorl, the ornamentation is somewhat finer than in that example. But as the Kansas shell is also somewhat smaller, the granules would necessarily be smaller also, and the variation from the Texas form, in ornamentation and angular divergence of slopes, indicated by this specimen does not, at furthest, equal that seen in *Turritella seriatim-granulata* Roem.

The measurements of the Kansas shell are: hight 14.5; breadth of the body-whorl 11.5 mm.; divergence of slopes (lower part of shell) 51 degrees.

PETERSIA MEDICINENSIS, sp. nov.

Shell of medium size, consisting of five or more (? six or seven) whorls, spire rather short, acute, equalling about or a little less than half the hight of the shell; whorls shouldered and ornamented with numerous closely-spaced, raised, revolving lines and with prominent but rather narrow vertical ribs or folds, of which latter there are about 14 on each of the lower whorls; aperture elongate, subquadrilateral, bent slightly backward below to form a very short or rudimentary notch-like canal, and with a somewhat similar rounded, everted notch at the upper (posterior) corner; spindle short; inner lip, within, bearing, opposite the middle of the aperture, two oblique, parallel, narrow, sharply-raised folds which do not extend outward to its slightly thickened and everted border; outer lip with a sharp, slightly crenulated edge, back of which the newest fold (in the stage of growth shown in the

younger, but more perfect, of the two type-specimens) forms a rib-like thickening.

Measurements.—Hight 21; breadth of body-whorl 11.5 mm; divergence of slopes 52 degrees,—these being the measurements of a young shell. An imperfect specimen, which perhaps represents nearly the adult size, indicates a hight of nearly 50 mm.

Occurrence.—In No. 3 of the Belvidere section, about a mile and a half south of the railway station.

There are 14 of the coarse vertical folds on the body-whorl and 13 on the first spire-whorl in the smaller of the type-specimens.

I am unable to refer this shell elsewhere than to the upper Jurassic genus, *Petersia*.

CAUSES AND CONDITIONS OF GLACIATION.

By WARREN UPHAM, Somerville, Mass.

At the meetings of the British Association in each of the past two years the causes of the Glacial period have been discussed from new points of view. One of these papers, presented in 1892 by Percy F. Kendall and J. W. Gray, is fully published by Mr. Kendall in the Transactions of the Leeds Geological Association for Feb. 16, 1893 (pages 53-70). This paper holds that the Glacial period came on with extreme slowness; that it was of long duration (an estimate of at least about 11,000 years being given for the time of growth of the European ice-sheet, and two-thirds as long for the North American); that the Glacial period ended very abruptly; that the level of the British Isles was nearly the same at the beginning of the Glacial period as now; that the end of this period was very recent in a geological sense (the estimates of 10,000 years, or less, for the Postglacial epoch, as drawn from the rates of recession of the falls of St. Anthony and of Niagara, being accepted); and that there has been only one epoch of glaciation. This review of the Ice age forbids an explanation of its causes by the astronomic theory of Croll, Geikie, and Ball. Against the American theory that great uplifts of the drift-bearing lands brought on their cool and snowy climate and glacial envelopment, and that final subsidence under the weight of the ice-sheets caused them to

be melted away, it is objected that the Pliocene and Pleistocene marine deposits of portions of the shores of Great Britain leave no room for such changes there in the relations of land and sea. The authors conclude, therefore, that the Ice age was probably due to great variations in the heat of the sun, but how these could be caused is left in uncertainty.

A second paper, presented to the British Association in 1893, was by C. A. Lindvall, a Swedish engineer of high attainments in his profession, whose attention during many years of observation has been much given to the problems of the glacial drift. His views had been set forth, however, two years earlier in a pamphlet of 48 pages, with five plates, published both in Swedish and English at Stockholm in 1891, entitled, "The Glacial Period: essay on its Origin, Effects, and End; as also the Possibility of its Recurrence." The drift deposition is ascribed to marine submergence with icebergs and floes, which are thought to have been borne over Scandinavia, a large portion of Russia, northern Germany, and the British Isles, while only the highest parts of the Scandinavian plateau rose as islands of the sea laden with the ice of Arctic currents. If such submergence should recur, Mr. Lindvall believes that an Ice age would be reinstated. Inquiring what were the climatic conditions of the earth during its earlier eras, he writes:

We then view our globe in the early dawn of time, a glowing mass surrounded by a thick veil consisting of almost all the water and other volatile matter on our earth, being kept in a gaseous form by the intense heat. With the intrepidity of youth it cares but little for the warmth of the sun, being as hot at the poles as at the equator. But spite of its covering it loses heat by radiation, and as the earth cools the effect of the sun becomes more and more preceptible......First at the poles and so gradually farther down, vegetable life commenced: this vegetation being accelerated by the heat of the earth beneath, pouring rain from above, and an atmosphere saturated with carbonic acid,—all to such an extent that we can show no parallel: but the product of course was luxuriant in due proportion........During all the periods of successive changes of climate and vegetable life in the polar lands, with the sole exception of the very latest period, a more or less broad belt has probably existed at the equator which was far too warm for plants or animals to exist there.

In Falsan's "La Période Glaciaire" (1889), of which a review appeared in the AMERICAN GEOLOGIST for July, 1890, an-

other theory of the causes of the Ice age is given, which makes it depend on high altitude of the glaciated regions, but draws attention especially, like Lindvall, to the changes in the relations of solar heat to the earth. This view, proposed by Dr. Blandet, and adopted by the Marquis de Saporta, Prof. de Lapparent, M. Falsan, and others, is presented in the following translation by Kendall in the Glacialists' Magazine for January, 1894:

The sun must certainly have passed through different states, and have produced at the surface of the earth various phenomena proportional to the magnitude of his successive diameters. With an apparent diameter of 47°, the distribution of light and heat, as M. de Lapparent has shown, would no longer correspond with the order of things established to-day. The differentiation of the seasons disappears, no part of the earth remains plunged in long nights, latitude loses a great part of its influence, the poles enjoy a mild temperature, and, at the torrid zone, the nebular state of the sun attenuates and compensates for the excess of heat which would have resulted from its proximity to the earth.... ......These facts once admitted, and it would be difficult to gainsay them, many geological problems find their immediate solution. It is no longer a strange anomaly to see the rich vegetation which has grown about the pole in ancient geological epochs, and even till after the Middle Tertiary times. One understands why, over all the earth and at all epochs, there succeeded a series of plants of which the uniform development was favored by the equability of climates and of seasons; how the plants have finished by disappearing from the poles, and by migrating to the south, when the sun, always concentrating upon itself, could send them only feeble and oblique rays. Then the climate of the poles was slowly modified, the seasons were progressively accentuated, and the atmospheric humidity was able to supply abundant precipitation of snow........By the effect of solar concentration and of the changes operating in the mode of distribution of heat, the new climatic conditions resulted in a state of unstable equilibrium. They could easily be modified by a host of circumstances previously of no effect, such as latitude, the variable action of marine and atmospheric currents, the orogenic movements of the earth, that is to say, the relief of mountains. These oscillations became stronger in proportion as the terrestrial crust acquired greater thickness, and they even acquired a preponderant influence in the establishment of glacial conditions.

A fourth theory, analogous with the three preceding, but more bold in its assumptions, disregarding many well accepted conclusions of geology, as the continuous descent and development of floras and faunas, including those of the sea, and supposing ice-sheets to have extended over even intertropical land areas, has been thought out by Mr. Marsden

Manson, a civil engineer of San Francisco, California. This ingenious and well argued hypothesis is published in volume VIII of the Transactions of the Technical society of the Pacific Coast (Sept., 1891), and separately, in a somewhat modified and more extended form, in a pamphlet of 49 pages, "Geological and Solar Climates, their Causes and Variations" (Department of Geology and Physics, University of California, May, 1893). Kendall reviews Mr. Manson's work as follows in the February number of the Glacialists' Magazine:

According to the author, during the early stages of cooling of the earth water-vapor would be present in the atmosphere in such quantities as to quite shut out the heat rays, though not the light rays, of the sun: and therefore the effect of the solar rays would be limited to heating the outside of a cloud shell, and so retarding the secular cooling of the earth. The cloud canopy would be effective in obstructing ingress as well as egress of heat rays. The isotherms would depend solely upon altitude and not at all upon latitude. As the earth slowly cooled, the isothermal shells would successively shrink down upon the surface. When the surface temperature was 90° F., "a particularly uniform, moist, and highly torrid climate was established,...... culminating in the Carboniferous age." With further cooling, temperatures corresponding with tropical and then temperate climates would prevail the world over. The isotherm of 32° F. would touch the mountain tops and a snow-line would be produced. "From the moment that snow began to accumulate, every remaining vestige of earth heat was available for producing those conditions favorable to glaciation, namely, warm seas, dense fogs, and cold continental areas: and every unit of solar energy reaching the upper regions of the atmosphere was available for maintaining those favorable conditions. Glaciation under these conditions would be cumulative until the oceans, exhausted of their heat and lessened in area, were no longer able to supply the moisture necessary to completely shroud the earth from direct solar heat."

The culmination of the Ice age, according to the author, was made by the gradual reduction of the waters of the oceans to a temperature of 31° F. down to the bottom, the present bottom temperature of the oceans, and the consequent reduction of evaporation permitted the sun's rays at last to break through, and to their heating power the disappearance of the ice-sheets is ascribed: but, just as the high specific heat of water kept the oceans warm long after glacial conditions had supervened upon the land, so now the same property retards their recovery under the genial influence of the radiant heat of the sun. In the author's opinion the climate of the whole earth is becoming warmer, and he appeals to the general retreat of glaciers in proof.

Each of these discussions doubtless presents, in greater or less degree, some useful portion or hint of the truth; but each

also seems to the writer to be, in important portions, erroneous. With acceptance of the review of the Glacial period as given by Kendall and Gray, there appears no warrant for their opinion that it was caused by a diminution, and ended by an increase, of the sun's heat. During the centuries of written history, and especially during the past century of critical investigations in terrestrial and solar physics, no variations of this kind have been discovered. Such a cause of the glacial accumulations would have enveloped Alaska and Siberia with ice-sheets and their drift deposits. The anomalous geographic distribution of the drift forbids this hypothesis. Prof. H. A. Hazen, of the U. S. Weather Bureau, in a paper contributed to the Engineering Magazine for March, 1893, shows that the climates of Palestine, Egypt, and China, have undergone no appreciable change during the past 3,000 to 4,000 years.

The fully proved land-ice origin of the general drift sheets in North America and Europe effectually opposes Lindvall's theory of the nature and causes of the Glacial period; and the remains of past life in the rock strata are discordant with his supposition concerning the torrid zone previous to the Quaternary era.

If we should accept Tait's and Newcomb's estimate, that the existence of the sun since its contraction past the place and time of its shedding off the matter which now forms the earth and moon, has been no longer than about ten million years, we should surely require for the geologic record all the time possible under that hypothesis. Life might then be supposed to have begun on the earth when the sun was so large as Blandet and Falsan suggest; but more probably the sun is vastly older, as one to two hundred millions of years, so that the solar contraction and intensity of heat became nearly what they are now before the time of the oldest known fauna of the Cambrian rocks, which, to judge from its stage of development, was far from the beginning of life on our planet.

The occurrence of many and distantly separated areas of late Carboniferous or Permian glaciation, marking the only time of wide prevalence of glacial conditions previous to the Pleistocene ice age, as reviewed by C. D. White in the AMERICAN GEOLOGIST (vol. III, pp. 299-330, May, 1889) and in

Wright's "Ice Age in North America" (pp. 435, 592), is inconsistent with Falsan's and Manson's views, which have no place for general glaciation before the Pleistocene period. Another obstacle to Manson's hypothesis of a continuous cloud envelope till after the Quaternary glaciation consists in the extensive deposits of rock salt and gypsum found in strata as old as the Silurian and Cambrian, since these beds could only be formed by evaporation of lagoons shut off from the sea, or of saline lakes, under a drying atmosphere.

The epeirogenic theory of glaciation, thought out by Dana, Le Conte, Wright, and other American glacialists, and by Jamieson in Scotland, which has been presented in the AM. GEOLOGIST (vol. VI, pp. 327-339, Dec., 1890; vol. XIII, p. 278, April, 1894), in "The Ice Age in North America" (pp. 573-595), and the American Journal of Science (vol. XLVI, pp. 114-121, Aug., 1893), is held by Falsan to account for the Glacial period, but it is rejected by the other authors here reviewed. The chief objection urged against it, which is presented, as before noted, by Kendall and Gray, consists in an approximate identity of level with that of to-day having been held by some drift-bearing areas at a time very shortly preceding their glaciation. This is clearly known to have been true of portions of Great Britain and of New England. In respect to this objection, it must be acknowledged that the preglacial high elevation which these areas experienced was geologically very short. With the steep gradients of the Hudson, of the streams which formed the now submerged channels on the Californian coast, and of the Congo, these rivers, if allowed a long time for erosion, must have formed even longer and broader valleys than the yet very impressive troughs, continuing to depths of 2,000 to 6,000 feet beneath the sea level, which are now found on these submarine continental slopes. But the duration of the epeirogenic uplift of these areas on the border of the glaciation for the Hudson, beyond it for the Californian rivers, and near the equator in western Africa, can scarcely be compared in its brevity with the prolonged high altitude held during late Tertiary and early Quaternary time by the Scandinavian peninsula and by all the northern coasts of North America from Maine and Puget sound to the great Arctic archipelago and Greenland.

The abundant long and branching fjords of these northern regions, and the wide and deep channels dividing the many large and small islands north of this continent, attest a very long time of high elevation there. At the time of culmination of the long continued and slowly increasing uplifts at the north, they seem to have extended during a short epoch far to the south, coincident with the formation of ice-sheets in high latitudes. But when these lands became depressed and the ice burden of the glaciated countries was removed, they in some instances, as in Great Britain and New England, returned very nearly to their original levels, beautifully illustrating the natural condition of equilibrium of the earth's crust, which Dutton has named *isostasy*, that when not subjected to special and exceptional stresses it acts as if floating on a heavier plastic and mobile interior.

In the great erosion of the Lafayette formation on the Atlantic coastal plain and Gulf border of the United States, and in the lower Mississippi basin, which formation is regarded by Hilgard, Spencer, E. A. Smith, and the present writer, as of early Quaternary age, formed during the initial stages of the high uplift that culminated in the Ice age, we have an impressive record of that epoch of great altitude of the northern and principal part of this continent. Similar rapidity of erosion must also have ensued when any moderate retreat of the ice-sheet during the time of high uplift and ice accumulation permitted much of its drift gravel and sand to be deposited, as in the valleys of the Ohio river and its tributaries, described by Chamberlin and Leverett in the April number of the Am. Journal of Science (also see the AM. GEOLOGIST for March, pages 217-219). With an elevation of that area probably 3,000 feet higher than now, giving its streams far more rapid descent, and with the aid of a dam formed by the ice-sheet crossing the Ohio valley at Cincinnati while most of the valley drift was being laid down, and the subsequent removal of this barrier while the stream erosion took place, we may well suppose that an interval of a few thousand years between the stages of ice advance would suffice for an amount of stream channelling many times greater than has been accomplished in the less abundant later deposits of valley drift during all the Postglacial epoch of low altitude and

gentle river currents. The same lapse of time would also suffice for the amount of leaching and oxidation of the earliest drift which Mr. Leverett has observed in sections of its former surface now covered by thick deposits of later drift in Illinois, Indiana, and Ohio (Proc., Boston Society of Natural History, vol. XXIV, pp. 455-459, Jan. 1, 1890). It may be true also that within this interval the rock gorges in northwestern Illinois described by Mr. Oscar H. Hershey in the AM. GEOLOGIST for November, 1893, were eroded; but it is necessary to scrutinize very carefully the evidences for such rock erosion during the Glacial period, lest preglacial channelling, done by small tributaries of the main valleys during the gradual uplift of the country leading to the Ice age and contemporaneous with the Lafayette erosion, be thus misinterpreted.

The complexity and great length of the Glacial period in Europe, with subdivision by interglacial epochs, which are taught by Prof. James Geikie in his admirable books and essays, and by Mr. Andrew M. Hansen in the Feb.-March number of the Journal of Geology (also AM. GEOLOGIST, vol. XII, p. 225, Oct., 1893), may probably be reduced to a much less time and to essential continuity of glaciation, interrupted as in America only by moderate fluctuations of the ice borders, when we consider the lesson of the Malaspina glacier or ice-sheet in Alaska, showing how temperate floras and faunas may be enclosed between deposits of till by oscillations of the ice front requiring no long time.

One remaining question, which Prof. R. D. Salisbury has recently asked in the Journal of Geology (vol. II, p. 222, Feb.-March, 1894), concerning the departure of the ice-sheet because of epeirogenic subsidence of the glacially burdened land, may be readily answered. Though the still high surface of the greater part of the ice-sheet would not be affected by the temperate climate of the country depressed to its present level or slightly lower, the warm summers along the ice border would cause it to be rapidly melted. This process extended inward until all the ice-sheet disappeared. When the progress of the marginal melting in the Mississippi basin had given generally steep gradients of the ice-front, its more powerful currents formed the retreatal moraines and the many lake

basins of the unevenly laid later drift which are so strongly contrasted with the smooth and attenuated outer portion of the drift sheet beyond the moraines.

THE PRESENT CONDITION OF THE EARTH'S INTERIOR AS VIEWED FROM THE STANDPOINT OF THE NEBULAR HYPOTHESIS.

By PROF. W. H. SEAMON, Rolla, Mo.

Although there are now but few, if any, geologists who would contend that the earth consists of a cold crust surrounding a melted interior, many of them, particularly writers of text-books, still teach that the earth's interior is very highly heated. While we do not find in any recent literature any positive statement as to the degree of heat, I am sure that I make no mistake, when I assert that Dana, Le Conte and Geikie, all give the impression, perhaps unintentionally, that the temperature of the earth's interior is so great that, were it not for the weight of the superincumbent crust, all of it would be in a molten condition, at a temperature much hotter than necessary for complete fusion.

Dana says: "The rate 1° F., for 60 feet of descent, in the latitude of New York, would give heat enough to boil water at a depth of about 9,000 feet; and 3,000° F., at a depth of about 33 miles. But the ratio is not an arithmetical one, because both of the greater conductivity of the earth below (owing to greater density) and the increased pressure, and hence the depth of fusion, supposing fusion a fact, much exceeds this amount; but how much, has not yet been determined."*

Le Conte says: "From the facts given above it is probable that the temperature of the interior of the earth is very great."†

After a very clear and able argument showing the effects of pressure in deepening the fusion level, if fusion exists at all, he says: "From this line of reasoning, therefore we conclude that the solid crust of the earth *must* be much thicker than is usually supposed, and there *may* be even no interior liquid at all."‡

*Dana's Manual of Geology, page 717.

†Le Conte's Elements of Geology, third ed. (1891), page 84.

‡Le Conte's Elements of Geology, page 86.

In another place we find: "It is a cool crust, covering an incandescent interior."*

Geikie says: "It was formerly a prevalent belief that the exterior and interior of the globe differed from each other to such an extent that, while the outer parts were cool and solid, the vastly more enormous inner *intensely hot*† part was more or less completely liquid."‡

In another place he says: "It appears highly probable that the substance of the earth's interior is at the melting point proper for the pressure at each depth. Any relief from the pressure, therefore, may allow of the liquefaction of the matter so relieved."§

Astronomical observations do not admit of a liquid interior, and compel the belief that the earth throughout is a rigid solid, except in certain localities which are most probably entirely within the outer crust, made liquid by the heat proceeding from chemical changes and mechanical movements within this crust.

There are but two good reasons for believing the earth's interior to be highly heated at the present time.

1. The gradually increasing temperature observed as depth in the crust is attained.

2. The nebular hypothesis requires a former very high temperature for the earth, making reasonable the assumption that much of this primary heat has been entrapped and retained beneath the crust.

The observations made in shafts and borings show an increasing temperature. But the results are very variable, and seem to confirm the impression that this increase may be entirely due to heat produced by chemical and mechanical action within the crust.

Those holding to the retention of much primary heat, have felt compelled to give reasons why the interior is not in a melted condition. The best reason given, the weight, or pressure of the superincumbent crust, only augments the difficulty of the explanation; for while pressure may prevent actual

*Le Conte's Elements of Geology, page 166.

†Italics are the writer's.

‡Geikie's Text Book of Geology, second ed. (1885), page 44.

§Geikie's Text Book of Geology, page 55.

melting, it will usually increase the amount of heat in the compressed body.

The crust of the earth possesses the properties of an arch, and, as it is composed of oxidized materials, it possesses a lower coëfficient of contraction than does the metallic interior. The contraction of the interior would, therefore, be greater than for the crust, for equal decrements of temperature; and instead of there being much pressure on the metallic interior, the probabilities are there is none, resulting from the weight of the crust.

It is the object of this article to show that, proceeding from the nebular hypothesis, the temperature of the interior cannot be as much as 3,000° F. at any point, except perhaps, but not necessarily, localities in the crust, whence proceed the fused materials ejected by volcanoes.

The nebular hypothesis of the earth's origin is so generally accepted, and appears to be so firmly based upon observations of celestial phenomena, that we should always consider it in our speculations as to the history and present condition of the earth's interior.

When the earth was in its nebulous condition, the temperature, though high, must have been nearly uniform throughout the nebulous mass. Matter in the gaseous form so readily diffuses, as shown in the present composition of the earth's atmosphere, moving most rapidly from hot to colder points, that it seems, even in so large a volume of gaseous matter as that of the earth in its nebulous condition, the temperature must have been kept nearly uniform, down to the time when it was condensed to the liquid state. At what temperature liquefaction began is a matter for speculation which I have not considered. It seems evident however that the first molten mass was mainly composed of the heavier metallic elements, while the lighter gaseous, alkali, and alkaline earth elements, still remained in their gaseous condition, uncombined with each other. The lamented Sterry Hunt, in an address before the Royal Institution, in 1867, generalized as follows: "The breaking up of compounds, or dissociation of elements by intense heat is a principle of universal application, so that we may suppose that all the elements which make up the sun, or our planet, would when so intensely

heated as to be in the gaseous condition, which all matter is capable of assuming, remain uncombined, that is to say, would exist together in the state of chemical elements." Perhaps the hydrogen, oxygen, carbon and nitrogen, may have been at that time, or an earlier period, in a condition as highly attenuated as the hypothetical ether now prevading space, which may be after all the only true elementary substance.

After the formation of the first molten mass, the earth would have been constituted very much like our present sun, a molten mass surrounded by a gaseous envelope of substances in their elementary condition. As the caloric of the gaseous envelope was radiated into space, it received heat from the molten interior. The temperature of this molten mass would not have varied much as to uniformity, since liquids carry heat quite readily by convection, tending to maintain a uniform temperature throughout their mass. In fact, the probabilities are that the molten mass was at first very small, and grew in size, as it and the surrounding envelope cooled and slowly condensed. Such a method of growth would have largely tended to maintain a uniformity of temperature. We may presume that this continued until the lighter metals began to condense. By the time this point was reached the oxygen would have to combine with them and other elements, forming acid and basic oxides, which would have readily combined with each other forming a fused magma. This magma, on account of its greater lightness, would have floated upon and protected the inner metallic mass.

On account of the high conductivity of the inner metallic mass, it would have poured off its heat to the oxidized magma as rapidly as the latter could receive it. This fused magma by convection would have tended to maintain the uniformity of its temperature; and the heat produced by the chemical combinations in the magma and in the atmosphere of the earth would have delayed solidification. Finally solidification of the crust began.

The first crust was of similar composition as diorite or syenite.*

Diorite melts at a temperature of about 2,000° C. As new experiments, with better pyrometers, have largely reduced the

*Le Conte's Elements of Geology, page 215.

formerly accepted melting points of many substances, we may expect this result for diorite to be reduced also. It therefore seems to me that we may assume the temperature of the earth at the period of the solidification of the crust to be about 3,000° F.

The temperature of the interior would have prevented a rapid thickening of this crust. After the crust had formed, the heat of the metallic interior would have still been rapidly communicated to the outer crust. It must not be forgotten that it was not a case of heating a cold crust; but that the heat from the interior had simply to continue to flow through this outer crust.

The following equation will give the present temperature of the earth's interior, as accurately as the factors can be determined.

$$\text{Present temperature of the metallic interior} = \frac{\text{Volume} \times \text{density} \times \text{sp. heat} \times \text{orig. temp.} \times 62.25.^{*}}{\text{Time of cooling} \times \text{area of radiating surface} \times \text{annual loss of heat.}}$$

Substituting in this equation the following values and solving, we obtain 468° F. as the present temperature of the earth's interior.

Specific heat of the metallic interior, 0.1.†

Specific gravity of the metallic interior, 9.

Time since crust began to form, 60,000,000 years.‡

Assumed average thickness of the crust during this period, fifty miles; diameter of the earth, 7,900 miles.

Temperature of the earth at the time the crust began to form, 3,000° F.

Amount of heat annually flowing through the crust, forty units of heat from each square foot of the radiating surface of the metallic interior.

In conclusion, I desire to say that I recognize that the results of my calculation may be criticised, owing to my inability to secure the exact values of the factors in my equation; yet that is not the material point of this article, which is intended to show, to the supporters of the nebular hypothesis of

*Weight of a cubic foot of water in pounds avoirdupois.

†This is above the average specific heat of the heavy metals.

‡Estimates of the age of the oldest stratified rocks vary from 10,000,000 to 200,000,000 years. See Geikie's Text Book of Geology, pp. 56 and 57.

the earth's origin, that there is no real necessity for assuming or believing that the internal temperature of the earth is high, but that instead it is most probably low.

NOTES ON SOME LOCALITIES OF MESOZOIC AND PALEOZOIC IN SHASTA COUNTY, CALIFORNIA.

By HAROLD W. FAIRBANKS, Berkeley, Cal.

Introduction. In the summer of 1891 the writer, while at work on the geology of Shasta county, was fortunate enough to make the discovery of several very rich fossiliferous localities which appeared to represent horizons previously unknown in that part of the state.* Some time later the extensive paleontological material was placed in the hands of J. P. Smith of the Leland Stanford University, who is at present at work on it in connection with a more detailed study in the field. The field notes are largely those of the writer, but he is indebted wholly to Mr. Smith for the determinations of the various horizons described.

General geology. Shasta county occupies the greater portion of the Klamath Mountain region which drains into the Sacramento river. The lava flows of northeastern California have covered the eastern half of the county, reaching nearly to the Sacramento river on the south, while in the northwest corner a small flow descended the valley of the same stream for a number of miles. That portion of the county to the north and west of Pitt river as far as Big Bend is wholly free from the lavas, and it is in this region that the richest fossiliferous beds occur. The mountain ranges have a north and south trend and rise from two to three thousand feet above the valleys, being very rocky but not precipitous. Although there is some timber the greater portion of the surface is covered with dense brush, making it difficult to traverse except over the old trails.

*The report on the geology of Shasta county containing a description of these discoveries would have been issued by the California State Mining Bureau in the winter of 1892-3, but owing to the refusal of the Governor to have the whole printed it was cut down and much of the geological portion left out.

The geological structure of the central and north central portions of the county, lying immediately west of the lava, is comparatively simple. In the regularity of strike and dip of the strata over considerable areas it more resembles that of the Sierra Nevada than the Coast ranges. Eruptives too are of rare occurrence in the north central portion, that region lying between Kosk's creek and the upper Sacramento. While so much of Shasta county is auriferous, there is hardly a trace of the precious metals in this region. The metamorphic series consists to a great extent of slates. Toward the western side of the county in the direction of the higher ranges of the Klamath mountains there is a considerable change in the character of the sedimentary rocks. Although there are large areas of slate, yet fine silicious conglomerates are very prominently developed. The strike and dip also become very irregular because of the many large masses of intrusive rock. It was in Shasta county that the Carboniferous was first recognized in California. Dr. Trask made a considerable collection from the Gray or Marble mountains near the mouth of the McCloud in 1854. Later work was carried on by Whitney's survey, but no important addition was made to our knowledge of the metamorphic series.

In 1883 J. S. Diller, of the U. S. Geological Survey, began work in this section of California, making collections from several new localities of Carboniferous limestones. In 1890, with more complete paleontological material, the limestones on Cedar creek were determined as Trias. In the summer of 1891 the writer found the first Jurassic fossils in place in the Big Bend region, although Mr. Diller had previously picked up float specimens near Kosk's creek.

Jurassic of Big Cañon. The youngest portion of this series of metamorphic rocks is found just west of the lava sheet, whose western border in the northern part of the county is Kosk's creek and Pitt river. Big Cañon enters the cañon of Pitt river a few miles below Big Bend, and in this cañon the first Jurassic fossils were found in place. The slates and shales vary from black to reddish brown in color, closely resembling the Jura of Taylorsville. The fossils were not abundant and consisted almost wholly of lamellibranchs. They were found in place and in float boulders in the creek bed.

The fossils were studied by J. P. Smith and pronounced to be the equivalent of the Hardgrave sandstone, Lower Jura, of Plumas county. It seemed probable that a much larger collection might be made from the upper portion of the cañon, but the thickness of the brush prevented at that time any farther investigation. The strata are vertical or dip at a high angle to the east, and strike nearly north and south.

Mr. Diller has also obtained fossils from other localities in the Big Bend region, apparently higher in the series, for Prof. Hyatt considers them as probably equivalent to the Mormon sandstone. The Bend formation then consisting of slates and argillaceous limestone embraces as far as is known the Lower and Middle Jura.

The Trias of Squaw Creek. Farther to the west, the divide between Pitt river and Squaw creek is capped by extensive limestone beds, which are greatly faulted and broken. The limestone begins to outcrop prominently on the south near the point where the trail from Madison's to Brock's crosses the divide. It extends northwards for about eight miles, when its course carries it across Squaw creek. It is known to extend to the divide south of the McCloud river. The beds are not absolutely continuous, but swell and contract in lens-like forms. The northern portion of the limestone and inclosing shales has a vertical dip, but about five miles north of Madison's the strata change their position, and the limestone in part caps the divide, dipping to the east at varying angles. The limestone presents bold cliffs several hundred feet high to the west, and reaches in places an elevation of 4,000 feet. On the summit a little north of the trail to Brock's the limestone rises in high and rugged pinnacles. Here a rich Triassic fauna was found. The fossils are chiefly cephalopods and are well preserved: a large number of species was collected, many of them being new. In a gulch at the southern extremity of the main limestone range there is an opportunity to study the transition from limestone to slate, made doubly interesting by the fact that some species in the limestone can be followed for several hundred feet into the argillaceous slate. These fossils were studied by J. P. Smith, who reported them to belong to the Karnic division of the Upper Trias, while the calcareous and argillaceous slates are proba-

bly of Lower Karnic age. The limestones are considered by him as the equivalent of those on Cedar creek, south of Pitt river. In relation to the Taylorsville Trias, he considers the limestone equivalent of the Hosselkus limestone, and the underlying *Ammonite* slates the equivalent of the Halobia slates. The conclusion based on a study of the field was that the Squaw creek limestone and associated fossiliferous strata occupy an intermediate position between the Jura of Big cañon and the Carboniferous of the McCloud. The argillaceous slate below the limestone is followed in the direction of Squaw creek by silicious slates, having a nearly vertical dip. In the latter, fully 2,000 feet below the limestone, several poorly preserved specimens of brachiopods were found.

The silicious slates continue southward and are probably the equivalent of those at Silverthorne's ferry, where there is an exposed thickness of nearly 2,000 feet. According to the paleontological evidence obtained here by J. P. Smith, he would place these slates in the Middle and possibly the Lower Trias, of which there are no equivalents at Taylorsville. It is intended to apply the term Pitt shales to these rocks, which, together with some Upper Carboniferous strata (McCloud shales), twenty miles above the Fisheries, shall be embraced under the designation Pitt formation.

The Carboniferous of the McCloud River.—The Gray or Marble mountains of the McCloud river, as a high and rugged range, border that stream for many miles on the east. In the vicinity of the United States fisheries the scenery is very picturesque. The limestone is much disturbed, in places being nearly vertical, in others dipping to the east at an angle of thirty degrees or less. Whitney estimated the thickness at the fisheries as 1,000 feet, but it seemed to the writer much greater, probably twice that amount. Dr. Trask collected the most of his fossils from near Basses ranch south of Pitt river, the limestone being the southern continuation of that on the McCloud.

The lowest horizon recognized at the fisheries is a black silicious shale, probably 500 feet thick (Baird shales), the fauna of which Mr. Smith considers analogous to the Waverly, but that the stratigraphical position is higher. The fauna is chiefly molluscan. This fauna seems to appear at a num-

ber of places below the limestone as far up the river as Campbell's. The shales outcrop most prominently on the west side of the river just above Baird P. O. Here they are very highly metamorphosed in places by dikes of diabase and diabase porphyrite. Four miles above, two specimens of trilobites were obtained from a dark calcareous shale. They were submitted to captain A. W. Vogdes, U. S. A., who stated that they were quite similar to *Proetus ellipticus* from the Lower Carboniferous of the middle states.

The limestone peaks along the east side of the McCloud extend in a north and south direction, but the strike of the strata is about north 30 degrees west. The repetition of the limestone bodies in the north and south direction, as well as that of the fossiliferous beds along the river, is undoubtedly due to sharp folding or faulting. If this were not so the thickness of the limestone would be immense. The McCloud limestones are considered by Mr. Smith as belonging to the Upper Carboniferous. The fauna consists chiefly of corals and brachiopods. Perhaps the best preserved specimens are to be obtained from the oldest known locality south of Pitt river. Fossils are however quite abundant in many places as far up the river as Campbell's. These limestone beds lie along an axis of great disturbance for at least twenty-five miles. At the southern extremity this disturbance seems to have been greatest, for in the vicinity of Basses ranch, south of the main limestone range, small areas of the rock appear separated from each other some distance, and inclosed in a variety of eruptive rocks. At the fisheries and many other points up the river, the limestone has been intruded by a great number of fine grained dikes. These seem to have come up underneath and to have very much broken the lower portion. In some places radial arms of limestone extend down from the main portion of that rock toward the river and are partly or wholly inclosed in eruptive masses. On stratigraphical grounds the writer would correlate the McCloud limestone with that found by Mr. Diller on Soda creek in the extreme northern part of the county. The McCloud limestones cross the river about sixteen miles above its mouth and are known to occur at several points in the high range east of the Sacramento river. The McCloud limestone is generally associated with rocks

quite different from that east of Squaw creek. On Campbell's creek the rock overlying the limestone appears to be a pseudodiorite, associated with others in a highly metamorphic condition. Nine miles above Campbell's the limestone strata are separated by layers of a hard feldspathic rock of a greenish color. Twelve miles to the north the overlying rock is a green to purplish conglomerate, very compact and hard. On Chatterdown creek occur quartzite, green conglomerates, and diorite. The great body of the rock seems semi- to fully crystalline. The field is undoubtedly an interesting one for the study of metamorphism.

The uppermost horizon of fossiliferous strata on the McCloud occurs about twenty miles above the Fisheries on the east side of the river. Here is found a calcareous argillite rich in several species of *Productus*, besides other forms, which according to Mr. Smith belong in the upper portion of the Carboniferous. These argillitic limestones and the associated shales are embraced under the designation, McCloud shales.

The Devonian of the Sacramento River. What is perhaps the oldest fossiliferous formation in this region is found west of the Sacramento river and near the station of Kennett. Here occur four or more detached limestone areas associated with green rocks and slates; areas probably once more or less continuous, but which have been broken apart by intrusive masses. The strike and dip of the inclosing rocks is exceedingly irregular. One body of fossiliferous limestone is crossed by the old trail from the Squaw creek to Kennett. The other most important ones lie on the mountain side between the Backbone creeks. The fossils found here are exclusively corals and the number of species is not large. Much of the limestone seems formed almost wholly of the coral fragments. In places a network of coral stems weathers out, almost completely covering the surface of the rock. The age of this limestone is probably Devonian, according to determinations made by the U. S. Geological Survey.

Geological Results. Mr. Diller has added largely to our knowledge of the geology of Shasta county. Several localities of Triassic and Jurassic as well as Carboniferous fossils have been reported by him. The age of the main portion of

the Klamath mountains, however, yet remains to be determined.

There are then probably four important geological horizons represented in this section: Devonian, Carboniferous, Trias, and Jura; the fossils showing the rocks to be successively older from east to west. The structural relations of the different horizons yet remain to be worked out. Whether unconformities exist is not yet known. It would appear that the regioń of greatest upheaval and disturbance lay to the west; that structurally the Klamath mountains are more distinct from the Sierra Nevada than has been supposed.

There is yet no proof of any granite or other crystalline rock in this region older than the sedimentary complex. The hornblende granite near the Fisheries, referred to by Becker and White as older than the sandstones underlying the Carboniferous, is probably younger, as it is fine-grained near the edges and terminates in ramifying dike-like arms. The age of the most of the granite of the Klamath mountains is not known. That of one of the eastern ranges, the Trinity mountains, is probably post-Jurassic.

ON A RECENT DIAMOND FIND IN WISCONSIN AND ON THE PROBABLE SOURCE OF THIS AND OTHER WISCONSIN DIAMONDS.*

By WILLIAM H. HOBBS, Madison, Wis.

In October, 1893, a son of Charles Devine found some bright stones while playing in a clay bank on the farm of Judson Devine which is located near the village of Oregon in Dane county, Wisconsin. These stones he took home and in November of the same year they were brought to me for examination. One of them proved to be a rough diamond, the others being quartz pebbles. The diamond is a slightly distorted rhombic dodecahedron with much rounded faces. It has an average diameter of about a quarter of an inch and weighs 3.83 carats. It is not perfectly transparent, but the grayish coloring matter which it contains is apparently superficial. The edges of the rhombic dodecahedron seem to be slightly

*Read before the Wisconsin Academy of Sciences, Dec. 30th, 1893.

truncated by the faces of the icosatetrahedron. Numerous irregular-shaped cavities appear on the faces of the dodecahedron and are probably etchings. Mr. Devine sold the stone to Messrs. Tiffany & Company of New York, and I have been informed by Mr. George F. Kunz that it would doubtless cut white but would not be entirely perfect. The stone has been placed uncut in the "Exposition Collection" of gems prepared by Tiffany & Co. Mr. Devine's farm, on which this diamond was found, is two miles south of the village of Oregon and about twelve miles south of Madison. It was found in the till or boulder clay of the Kettle moraine. The residue of this material after elutriation to free it from the more finely comminuted matter, is found by microscopic examination to be composed of rounded quartz grains of variable size with a few oxidized grains of pyrite.

Considerable interest attaches to this find when considered in connection with other Wisconsin finds of diamonds. In 1876 a stone was found while digging a well on the farm then owned by Dr. Tucker in the town of Eagle near Waukesha.* In November, 1883, Mrs. Clarissa Wood sold the stone to Col. S. B. Boynton, a Milwaukee jeweler, for one dollar, neither party to the transaction knowing that the stone was a diamond. When it became known that the stone was a valuable diamond, suit was brought by Mrs. Wood against Col. Boynton for its recovery. The case was carried to the supreme court of the state and decided in favor of the defendant. The stone is still uncut in the hands of Col. Boynton, who now resides in Chicago. Through his courtesy I have been allowed to examine it. Like the Oregon stone, this diamond is a rhombic dodecahedron with rounded faces. The faces are sometimes vicinal, indicating a hexoctahedron of irrational indices. The faces also occasionally exhibit peculiar circular markings and low elongated triangular protuberances not altogether unlike those sometimes seen on the rhombohedral faces of amethyst. The crystal is but little distorted, is very transparent, and has a wine yellow color. On one side is a small flaw, apparently superficial. The weight of the rough

*Min. Res. of U. S. for 1883 and 1884, p. 732. (1885.)
Cf. also Geo. F. Kunz, Gems and Precious Stones, New York, 1890, p. 35.

stone is about 16 carats. Col. Boynton has given me the following facts concerning the section of material penetrated by the Eagle well in which this stone was found. Loose gravel extends from the surface to a depth of 25 feet. This is followed by 45 feet of clay. Below the clay is a layer 6 feet thick of hard yellow "matrix," which is doubtless gravel or clay cemented by oxide of iron. It was in this material that the diamond was found. Below it the well was sunk for two feet through clean gravel. Two small diamonds are said to have been subsequently taken from the well. There is also a report of a stone that is said to have been found when the well was begun in 1868. It was the size of a robin's egg. Parties who saw both this stone and the Eagle diamond claim that the only noticeable difference was in size. This stone may have been a diamond, but the evidence is insufficient.

While prospecting for gold in the summers of 1887, 1888, and 1889, Mr. G. H. Nichols of Minneapolis and two companions found a number of small diamonds in the bed of Plum creek in Rock Elm township, Pierce county.* Three of these stones, weighing 25-32, 7-16, and 3-32 of a carat respectively, were sent to Mr. Kunz for examination. All were found to be hexoctahedra and either white or yellowish.

I am informed by Col. Boynton that a diamond very much like the Eagle diamond was found in 1884 by Henry Endlich on his farm at Kollsville near West Bend in Washington county. Mr. Boynton describes this stone as wine yellow and of the same form as the Eagle diamond. It was harder than emery and weighed 21¼ carats. The same hard yellow ferruginous "matrix" which is found in the Eagle well occurs on Mr. Endlich's farm at Kollsville. I learn by correspondence that Mr. Endlich has since died and his family has moved away from Kollsville. I have not yet succeeded in getting into communication with any member of the family, but I think there can be little doubt that the stone found by Mr. Endlich was a diamond.† At the time Mr. Boynton examined the stone he was in possession of the Eagle diamond, and he

*On the occurrence of diamonds in Wisconsin, Bull. Geol. Soc. Am., vol. 2, p. 638. (1891.) Cf. also Min. Res. of U. S., 1889-90, p. 446. (1892.)

†Since the above was written, I have learned that Mrs. Louie Endlich of Kewaskum, Wis., now has the stone, but I have had no opportunity to examine it.

tells me that after it came into his hands he gave considerable attention to the properties of gems.

Diamonds have then been found at four widely separated localities in the state of Wisconsin, namely: at Eagle in Waukesha county, at Kollsville in Washington county, at Oregon in Dane county, and on Plum creek in Pierce county. In the last mentioned locality the stones were found in the bed of a stream within the area of the older drift, perhaps twenty miles from the Kettle moraine. The other localities are on the Kettle moraine of the Green bay lobe of the ice-sheet, as may be seen by reference to figure 1. Supposing

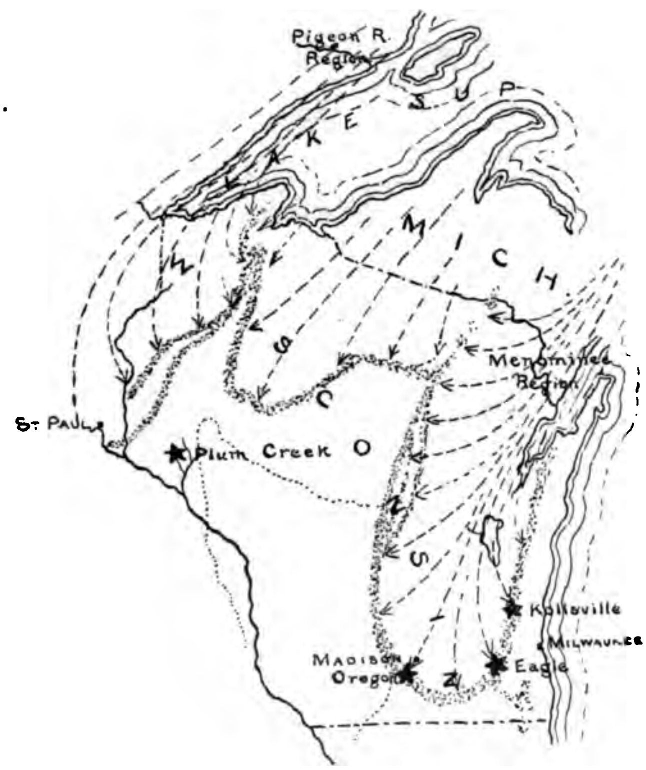


Fig. 1. Map of Wisconsin showing localities where diamonds have been found. The location of the Kettle moraine and the margin of the older drift are based on Chamberlin's maps. The directions of the glacial striæ are taken from the same source.

that the diamonds which have been found in the Kettle moraine have a common source, as is probable, they must have been derived from some area in the northeastern portion of

the state or a region still farther to the northward, as is clearly shown by the glacial striæ. The Pierce county diamonds are unlike the others described in that they are all small and occur in hexoctahedral instead of dodecahedral crystals. They could only be considered to have the same source as the others by supposing that all are derived from some area well toward the Hudson bay country in Canada.

It is interesting here to note that in the Menominee region on the northeastern boundary of Wisconsin are basic intrusive rocks which cut shales containing considerable percentages of carbonaceous matter, thus reproducing the conditions which obtain at the South African diamond mines. Very similar conditions obtain in the Pigeon river region northwest of lake Superior. The Pierce county diamonds may be easily conceived to have come from the latter area. It is not at all improbable that productive diamond mines may sometime be located in one or the other of these areas. In the meantime diamonds will be found occasionally in the drift. There is little to be hoped for in the systematic search for stones in the moraine, as they are probably disseminated with considerable uniformity through it. This would seem to be shown by the occurrences that are known.

DIFFERENTIAL FAULTS.

By William H. Hobbs, Madison, Wis.

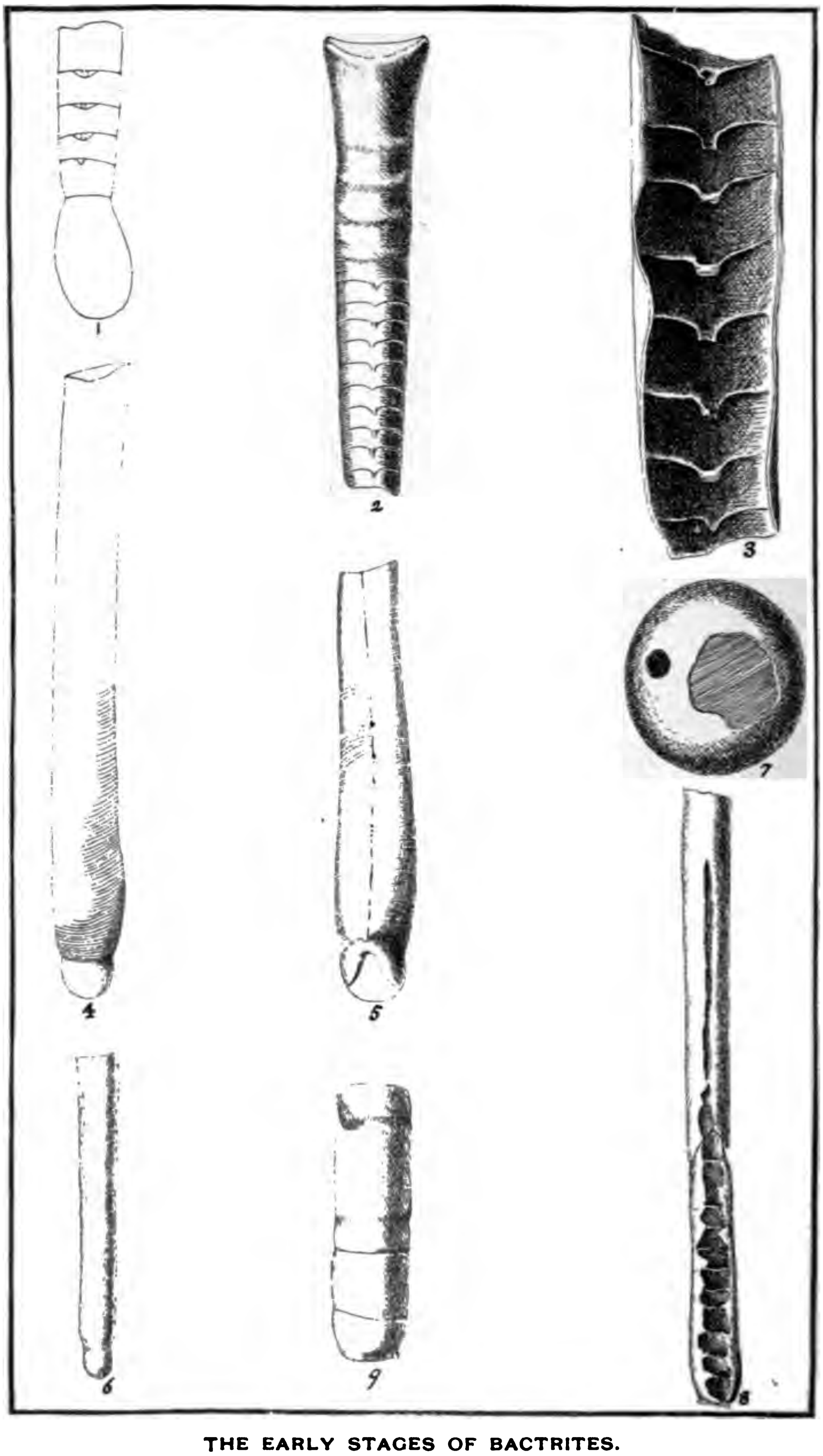
The dislocations of the earth's strata are generally classified, (1) according to the direction of the fault line with reference to the strike of the beds, into strike faults, diagonal faults, and cross faults; and, (2) according to the direction of hade with reference to dip, into vertical faults and faults with inclined hade. The latter type is further classified, (a) according to the direction of throw of the hanging wall, into normal and reversed faults or overfaults; and, (b) according to the relation between the hade and the dip of the beds, into faults which hade with the dip and faults which hade against the dip. Margerie and Heim in their admirable resumé of our knowledge concerning faults,* distinguish two main types

*Margerie et Heim. Les dislocations de l' écorce terrestre. Essai de définition et de nomenclature. Zürich. 1888.

of faults, namely, those resulting from vertical movements, and those resulting from horizontal movements in the earth's crust.

None of the above classifications takes into account the inclination of the crest and trough lines, or in other words the *pitch*, of folds of strata, and it is evident that a new type of fault is found if the pitch of folds is different in the two limbs of an inclined strike fault. An instance of this kind I have recently described from the southern extension of the Green mountains in Massachusetts and Connecticut.* The fault described is a strike fault and one resulting from horizontal movements. Its course is roughly north-south, following for a considerable distance the direction and approximating the position of the Housatonic river. It has an inclined hade uniformly east, throughout the twelve miles that it has been studied. Throughout this distance no noticable pitch of the folds is observable to the eastward of the fault line and consequently a single horizon—the Canaan dolomite—is exposed. A steep northerly pitch, however, characterizes the folds to the west of the fault line, so that not only the Canaan dolomite but two superior beds—the Riga schist and the Egremont limestone—appear along the fault line to the northward, and two inferior beds—Cambrian quartzite and gneiss—lie along it to the southward. For a part of its course Canaan dolomite lies on both sides of the fault line. Somewhere within this stretch of the fault line is a point at which there has been no displacement, but about which the western limb of the fault has suffered a differential movement like that of a lever about its fulcrum. As the arm to the north has been depressed, that to the south has been elevated. It is therefore only to the northward of this point that the fault is of the true reversed type. To the south of the fulcrum point the relations observed to the north are reversed. The eastern or hanging wall is downthrown and the western or foot wall is upthrown. These relations correspond to those of the normal fault, since a vertical line would penetrate any given horizon but once. The amount of throw increases pret-

*Wm. H. Hobbs. On the geological structure of the Housatonic valley lying east of mount Washington. Journ. of Geol., vol. I, pp. 793-798. (Nov.-Dec., 1893.)



THE EARLY STAGES OF BACTRITES.

ty uniformly in going either to the north or to the south from the fulcrum point.

The unique feature of this fault is the differential movement of the western limb with reference to the eastern one, and I therefore propose to call it a *differential fold fault.* Mild cases of this type of fault are probably by no means rare in mountain districts, but they would usually escape detection on account of the low angle of pitch. As more attention is given to the pitch of folds in the study of mountain structure, it may be expected that pronounced instances of such faults will be occasionally discovered.

THE EARLY STAGES OF BACTRITES.

By JOHN M. CLARKE, Albany, N. Y.

(PLATE II.)

In a recent number of this journal* the writer took occasion to describe the protoconch of a Devonian species of *Orthoceras*, remarkable for its fullness and rotundity, without evidence of distortion or shrinkage. In connection with this description reference was made to the similarity of form existing between this protoconch and that of the genus *Bactrites*, as represented by specimens from the same geological horizon.

The protoconch of *Bactrites* has been described by Branco† from specimens derived from the Wissenbach slates. This eminent cephalopodist mentions eight examples retaining this initial shell, in material which had been furnished to him by Privy-counselor E. Beyrich, and the figured examples show this protoconch to be an elongate, egg-shaped body, the shell-tube being attached at one of its extremities. The more complete of these figures, which is here reproduced in outline, shows this form as well as the narrowness and regular upward expansion of the shell-tube, and also the lateral position of the sipho, which has commonly been regarded as the principal determinative feature of the genus.

The ovoid form of the protoconch is, as observed by Branco, unlike anything occurring in the Ammonitinæ or the

*AMERICAN GEOLOGIST, vol XII, pp. 112-115, Aug., 1893.

†Zeitschrift der deutsch. geol. Gesellsch. vol. 37, pp. 1-9, figs. 1, 2, 1885.

Goniatitinæ, except in the genus *Mimoceras* (*Goniatites compressus*), where, in addition to this peculiar form of the protoconch, the initial portion of the shell-tube is straight, the primary volution free and the umbilicus open. Before the record of this observation, considerable divergence of opinion had been expressed by authors as to the phyletic position of *Bactrites*,* many choosing to associate it with *Goniatites* among the ammonoids. Beyrich (1851) regarded the genus as an orthoceran with marginal sipho, and this view was shared by F. Roemer, Owen and Quenstedt. In 1877 Barrande figured† as *Bactrites hyatti*, what was believed to be the initial extremity of a specimen which had been found in the Munich university collection, labelled *B. gracilis* Sandberger, and drawings of which had been prepared for him by Hyatt. These figures, however, show that the specimen bears no protoconch, but begins with a tapering, conical chamber having a cicatrix on its distal surface. Branco, in 1880 (Palæontographica, *ut cit.*), while expressing some doubt as to the generic relations of the Munich specimen, stated his conviction that, should this prove a genuine *Bactrites*, there could then be no question of its close affinity to *Orthoceras*. The description of the Wissenbach protoconchs a few years later dispelled this view.

An anticipatory glance at the figures here given of protoconch-bearing specimens of *Bactrites* will serve to show not only a difference in the form of this body and that ascribed to the genus by Branco, but also the very close similarity between it and that of *Orthoceras*, as given by the writer, and that of *Belemnites* as given by Branco.‡ These differences in the initial stages of shells ascribed to *Bactrites* lead first to the inquiry as to which of all these specimens really belong to this genus, for it would seem that all cannot. Branco showed§ at some length and quite conclusively that the Munich specimen figured by Barrande could not be accepted as a representative of this genus. With equal lucidity he indicated the

*For a summary of these opinions see Branco, Palæontographica, vol. 27, p. 49, 1880.

†Cephalopodes: Etudes Génerales, pl. 490, fig. 1; p. 120.

‡Zeitschrift der deutsch. geol. Gesellsch. vol. 32, p. 608, fig. 7, 1880; also Palæontographica, *ut cit.*

§Zeitschr., *ut cit.* vol. 37, 1885.

points of agreement in his specimens with the diagnostic characters of *Bactrites*. Though not venturing to determine their specific characters, he felt that the evident marginal position of the sipho was sufficient to establish their generic relations. Against this interpretation the writer can urge nothing, but only set forth the character of the material which has passed under his own observation.

Bactrites, as defined by its founder, G. Sandberger (1841), is based upon the species *B. gracilis* G. Sandb., the original localities of which are Wissenbach and Büdesheim. The shells of the genus are long, slender, slowly expanding tubes having an elliptical cross section, gently oblique septa, somewhat expanded aperture and the surface covered with fine concentric lines, which are more or less oblique and make a slight retral bend above the position of the sipho. As specimens are usually preserved, the sipho appears to be distinctly marginal. Upon internal casts of the shell the sipho seems almost invariably to make a distinct lobe in the margin of the septum. The structure at this point, however, is delicate, and such casts may readily convey an inexact conception. The position of the sipho is not precisely marginal, but a very narrow moiety of the septum lies between the tubular siphonal collar or funnel and the wall of the shell. A very slight variation in the direction of this collar, which is often perfectly apparent in any single specimen, will, in case of an outward inclination, attach the collar to the shell-wall, but if the direction be inward the collar may remain altogether free from the shell. This structure is seen in the accompanying figure (Plate II, fig. 3). The detachment of the shell-wall usually, indeed almost invariably, carries with it the outer portion of the collar, thus forming very distinctly an apparent dorsal lobe. It is the presence of this lobe that Branco has taken as giving the generic status to his specimens.

The material upon which the observations here made are based has been derived from the Naples beds or the horizon of the *Goniatites intumescens* fauna, in various localities in Ontario and Livingston counties, New York. Its representation is abundant and its preservation exceptionally favorable. A few of the specimens are preserved in pyrite, some are in limestone and shale, but the great majority are exquisitely

retained replacements in silica. These silicious fossils are differently preserved, many of them are simple replacements of the shell in all its parts, without the filling of the interspaces; others have the silicious shell retained in connection with a silicious filling of the internal cavities, though the depositions are discrete and were evidently successive; by the breaking of the external shell the internal filling can be readily removed. Again, the silicification of the shell has frequently been continued into an internal thickening which may more or less completely fill the chambers, though usually leaving the siphonal cavity unclosed. In this material there are twenty-four examples which retain the protoconch; many of these are not mere parts of mature individuals, but the young shells themselves. These specimens represent at least two distinct species of *Bactrites*, one a long, styliform shell, with decidedly elliptical cross-section and comparatively distant septa; the other a more rapidly expanding shell, subcircular in cross-section and with closer septa. The former, I am disposed to believe, includes the specimens from this horizon which have been described as *Orthoceras* and *Coleolus aciculum* Hall, probably also *O. aciculoides* Clarke, and some portion of the specimens which, in the absence of determinative material, have been referred to *O. pacator* Hall. The latter is a species which is hardly distinguishable from Sandberger's *B. gracilis*. Not only does it possess the contour and proportions of the specimens described by him,* but it also bears the characteristic surface sculpture over all the earlier shell growth, "sehr feine schräg zum Rücken laufende Linien," and upon the later growth, especially the body chamber are "verwaschene, wellig-heraustretende, schräge, breite Querrippen auf den Seiten, welche zu einer stumpfwinkeligen Dorsalbucht zusammenneigen." Without entering into a more detailed account of the specific features of these specimens, it will serve our purpose to regard them as representing *B. gracilis* Sandb.†

Protoconch. This is a bubble-shaped body, frequently a

*Verstein. des rhein. Schicht. Syst. Nassau, p. 130, pls. xi, figs. 9a, b: xii, figs. 2, a-f: xvii, figs. 5, a-e, 1856.

†This species occurs at a corresponding horizon on the Iberg and elsewhere in Germany.

little unsymmetrical or directed to one side, very broadly sessile upon the end of the shell-tube, from which it is separated by a sharp constriction. Its form is uniformly globose or subspherical, without the slight diminution in diameter or tapering, which is seen in the protoconch of *Orthoceras* described from the same fauna, as well as in that of *Belemnites*, as figured by Branco. In all these, however, the degree of constriction at the base of the protoconch is the same. Figures 4 and 5, which represent the usual form of this body, are taken from specimens in which the original shell has been replaced; figure 6 is from a smaller individual and shows a decidedly broader constriction at the first septum and a relatively less diameter in proportion to that of the shell-tube. This is a solid internal silicious cast, but the difference in retention will not explain the differences in size and form. Figures 4 and 6 have the same degree of enlargement, and while specimens like figure 6 are not uncommon, they all have a uniformity in size, at times the protoconch being even less clearly defined than here. These differences may be specific, or perhaps the smaller protoconchs and young shell-tubes may be parts of more fully grown shells, and have suffered diminution in size from resorption.

First septum. Frequently the delicate protoconch is broken and such specimens have afforded means of determining the fact that the opening of the sipho in the first septum is distinctly lateral, as shown in figure 7. This is an important distinction from the character of the first septum in *Orthoceras*, where the opening of the sipho is central. None of the specimens studied have afforded means of determining how the sipho begins, or whether a cicatrix exists upon the distal surface of the septum.

Initial Shell-tube. The *Oncoceras-* or *Gomphoceras*-like swelling of the shell-tube directly above the protoconch is one of the most striking features of these shells. In specimens of *B. gracilis* it is highly developed and a persistent feature. The increase in diameter from the first septum upward is quite rapid for a distance of two air chambers, and thence falls rapidly away. I speak of this as an *Oncoceras*-like expansion, for its form, usually unsymmetrical, suggests that genus and may afford a key to its phyletic position. It may

be observed that the last septa of *Oncoceras* crossing the expanded portion of the tube are frequently crowded together in a closer juxtaposition than elsewhere in the shell. Such a rapid recurrence of the septa is construed by Hyatt as an evidence of degeneracy or senility.

This expansion is less developed in *B. aciculum*, but its presence is evident. In Branco's figure, however, there is no such feature, the tube in the vicinity of the protoconch being narrower than at any other section.

Ornamentation. The fine, oblique thread-like lines which cover the surface are readily distinguished to the very base of the protoconch (figure 4). Toward the later parts of the shell they become more distant, gradually less distinct, and near maturity are lost or extremely obscure, becoming merged into the low, oblique undulations of the surface over the body chamber of the mature individual. In *B. aciculum* there are periodic internal annular thickenings of the shell substance, which are even manifested on the minute example shown in figure 9 (an internal cast in pyrite), but similar developments have not been observed in *B. gracilis*.

Whatever may be the apparent discrepancies in Branco's determination of the *Bactrites* protoconch and that here given, it may at least be said for the material here studied that it corresponds, even to its specific characters, with that upon which the genus was established. If the evidence presented brings us to the conclusion entertained by many of the older palæontologists, that *Bactrites* is closely related to *Orthoceras*, this conclusion is attained, by means of data not before elaborated, namely, the existence in both of like protoconchs. This fact, fortified by the decisive evidence that in *Bactrites* the sipho is strictly intra-marginal, the formation of a dorsal lobe wholly casual, leads to the conviction that *Bactrites* is little else than an orthoceran nautiloid with a lateral sipho. Both Branco* and Hyatt† have suggested the probability of *Belemnites* having been derived from orthoceran stock. Hyatt demonstrates that the guard or rostrum in this genus is a hypertrophic secondary deposition about the earlier parts of the

*Palæontographica, *ut. cit.*

†Proc. Amer. Assoc. Adv. Sci., vol. 32, p. 337, 1884; and Science, vol. 3, p. 124, 1884.

true conch, similar to the plug which is sometimes found filling the distal fractured extremity of the sipho of orthoceratites. The similarity of structure in the true conch of *Belemnites*, *Bactrites*, and *Orthoceras*, is now increased by the demonstration of like protoconchs in all.

EXPLANATION OF PLATE II.

FIG. 1. A reduced copy of Branco's figure of the protoconch of *Bactrites*. x20.

FIG. 2. Dorsal view of an internal calcareous cast of *B.* cf. *gracilis*, showing the usual appearance of the sutures, the undulations of the body chamber and the expanded aperture. x½. Naples, N. Y.

FIG. 3. Interior of a portion of the shell of *Bactrites* cf. *gracilis*, showing the intra-marginal position of the siphonal collar. x4. Honeoye Lake, N. Y.

FIG. 4. A shell retaining the protoconch and showing the expansion of the initial tube and the ornamentation (*B.* cf. *gracilis*). x16. Honeoye Lake, N. Y.

FIG. 5. Dorsal view of a shell with a fractured protoconch, the tube itself being broken along the line of the sipho (*B.* cf. *gracilis*). x16. Honeoye Lake, N. Y.

FIG. 6. Internal cast of a protoconch-bearing shell, probably *B. aciculum*. x16. Honeoye Lake, N. Y.

FIG. 7. The distal surface of the first septum (somewhat broken), showing the lateral position of the sipho. The margin of the septum on the left is the line between light and shade. x50.

FIG. 8. A *Bactrites* broken along the dorsum, exposing ten septa, some of which retain the siphonal collar: also showing the expansion of the shell just above the detached protoconch. x16. Honeoye Lake, N. Y.

FIG. 9. An internal cast in pyrite of a young *Bactrites* (*aciculum*), with body chamber and two air chambers. x16. Middlesex, N. Y.

EDITORIAL COMMENT.

DEATH OF MR. WM. PENGELLY.

To geologists and archæologists alike the news of the death of Mr. Wm. Pengelly, of Torquay, England, will be cause of regret. Mr. Pengelly was so well and so long known as the patient and thoroughgoing explorer of Buxham cave and Kent's cavern, under the auspices of the British Association, that it seems as if a conspicuous figure had disappeared from the field of science. His strong personality and utter engrossment in the work to which he devoted the last thirty years of

a long life combine to render him familiar and memorable to all who shared his enthusiasm. To his labor science owes the firm establishment of the doctrine of the antiquity of man on a base which can never again be shaken. He went through the storm that assailed him and his fellow workers when they announced their then unpopular doctrine, and lived to see the opposition dwindle down till it has now almost disappeared, except where thought and reason do not hold sway. Hours spent daily in Kent's cavern for thirteen years are commemorated by hundreds of boxes in his house, "Lamorna," Torquay, and piles of specimens exhibited in cases of the museum in the town. But to the scientific world outside, his elaborate yearly reports to the B. A. A. S. will form his monument, "more lasting than brass." E. W. C.

The Columbian Exposition.

Exhibits of the Geology of Canada.

Besides the Geological Survey exhibit of minerals, rocks, fossils, precious stones, and building materials, all of which were from the Dominion as a whole, there were separate exhibits from Canada representing the resources of British Columbia, the Northwest Territories, Ontario, Quebec, New Brunswick, and Nova Scotia. Each province had its mineral exhibit by itself, whilst the Dominion Geological Survey occupied a limited amount of space not far from the other Canadian products of the mine. There was exhibited, on behalf of the Government Survey, an extensive series of rock specimens illustrating the lithological characters of the Laurentian, Huronian and subsequent systems down to Post-Tertiary and recent deposits. There were no less than 1,411 rock specimens properly labelled, described and catalogued, giving an excellent opportunity to see the nature of the formations from the Atlantic to the Pacific and from the international boundary line to the Arctic ocean.

The palæontological collection consisted of 2,446 specimens of fossils, representing nearly *seven hundred* genera. These were classified both chronologically and zoologically, and formed an attractive as well as interesting exhibit, by far the most extensive and comprehensive collection of fossil remains in the Mining building. The specimens were exhibited in neat hardwood and glass cases, which we understand are to

be used for the formation of a new museum at the Canadian National Rocky Mountain Park at Banff in Alberta. There was also the graphite exhibit by the Dominion Plumbago Co., besides the collection of Canadian precious stones and gems. The collection of *Eozoön canadense* DAWSON formed a conspicuous feature of the palæontological series.

Then came the provincial exhibits. Quebec was conspicuous with its admirable and attractive display of asbestus, mica, and apatite, and of iron and copper ores.

British Columbia, with its gold, silver, lead, and copper-bearing rocks, was conspicuous by the neatness and attractiveness of its exhibit. A tall pyramid of gold bricks (models), as a trophy, stood alongside the beautifully classified ores of silver, lead, and copper. Each district was well represented, Kootenay, Kaslo, Lardeau, Big Bend, Kamloops, etc.; whilst the coal of the celebrated Nanaimo and Como collieries was all that could be desired.

Ontario had a superb exhibit of nickel, its ores and products. Blocks weighing 6,000, 8,000, and 12,000 pounds, were placed alongside the magnificent display of ore in the matte of calcined and partially reduced nickel ores, along with the refined metal and products therefrom. This was certainly the finest display of nickel ore which the world has ever seen. Ontario was also well forward with its iron, apatite, and mica, besides lithographic stones, petroleum, salt, and copper.

As to Nova Scotia and New Brunswick, these two maritime provinces were not as well represented as might be. Nova Scotia with her coal, gypsum, iron ores, and other products, could have made a much better showing. New Brunswick had building stone and gypsum amongst its leading products of the mine, besides ores of manganese.

The Northwest Territories of Canada, including Alberta, Saskatchewan, Athabasca, and Assiniboia, had building stone, coal, tar, and clays, as special products; but these were not shown to great advantage.

Nevertheless, on the whole, Canada's mineral wealth was well displayed and showed not only that ores are plentiful in many districts, but also, by accompanying notes of assays of these ores, that many of them are of high grade and quality.

H. M. A.

The Crystalline Rocks.

The descriptions already published in this series have given some of the features of the exhibits of the crystalline rocks, which might otherwise be mentioned here. The purpose of this note will be to supply some interesting facts that have not been noted

One of the largest collections of the products of the crystalline rocks was found in the exhibit of the Canadian Geological survey. It was under the care of Dr. A. R. C. Selwyn, aided by several of the officers of that survey. It embraced about 1,500 specimens illustrative of the Archean, from Nova Scotia to the Pacific coast. A unique feature here was a full series of all the forms of the world-famed *Eozoön canadense*, which are preserved by the survey to illustrate a historical episode in geological literature.

Another interesting series consisted of serpentine, of various structures and colors, in many cases cut by asbestos veins, in others produced by change from Eozoön limestone. The former is from Thetford and the latter from Petite Nation. Dr. T. Sterry Hunt, in his discussion of the Canadian serpentines, divides them into two groups.* The older he considered non-chromiferous, and the latter carries much chromic iron.

There was a very singular structure exhibited from the Little Rapids and High Rock phosphate mines, Portland, Quebec. Very many pyroxene masses, somewhat rounded, are embraced in a granite; and sometimes these dark masses so penetrate the rock in sheets as to give it a stratified aspect. These appeared to be exactly like those dark masses so frequent in acid crystallines, which have been assigned sometimes to "concretionary" forces. But this structure is in keeping with the idea that this rock was formerly a stratified conglomerate.

Beautiful large slabs of white orthoclase containing garnets were exhibited from Buckingham, and apatite and mica in large crystals from the Lake Gerard mine, Wakefield. One mica crystal was thirty inches in diameter and eight inches thick. There were also tourmaline crystals six inches and

*Geology of Canada, 1863, p. 608 *et seq.*

more in length, largely changed to mica, also to pure quartz. These were from Villeneuve, Quebec.

In the Canadian Survey exhibit was an instructive map, which under the animated explanation of Dr. Selwyn was made to point an interesting geologic fact. This map was made by Mr. H. Fletcher, and covered an Archean area in Nova Scotia and Cape Breton, an area which is most thoroughly worked in respect to the relations of the parts of the Archean. Dr. Selwyn is thoroughly convinced of the correctness of Mr. Fletcher's view, that there is no possibility of separating the Canadian Huronian from the Laurentian by any stratigraphic distinction, such as a non-conformity. Mr. Fletcher has despaired of making any fixed stratigraphic separation. His map shows one color for both, but they are marked by the letters A and B, meaning upper and lower Archean. The passage from one to the other is gradual whenever the stratigraphic succession is examined, but local irregularities occur.

Under "Laurentian," H. A. Ward had a show of *Eozoön* and, strange to say, *Cryptozoön proliferum*, from Saratoga, N. Y., labelled from the "Potsdam." That is a well-known Calciferous fossil. The tendency to crowd the term Potsdam upward, apparently to make it cover the western so-called Potsdam, which is near the Calciferous, is absurdly exemplified in this fossil, since its western analogue, *Cryptozoon minnesotense*, is found only in strata far above even those western strata to which the term Potsdam has been applied. At that rate, the whole of the northwestern Upper Cambrian must be included under the term "Potsdam;" and the Lower Magnesian, with its subdivisions, and the intervening sandstones, will lose their significance as coördinate members of the Cambrian. It would be difficult to extend the effects of a stratigraphic misnomer to a greater extreme. The *Cryptozoön* in Ward's collection was very fine, some large lenticular pieces being sliced and polished. These were put in juxtaposition with *Eozoön* because of their apparent structural organic resemblance, and it was indeed quite obvious. It may be said that the discovery of *Cryptozoön* furnishes a strong argument for the original claim of *Eozoön*. N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Report on Irrigation. By R. J. HINTON, Special Agent in chargé. Government Printing Office. Washington, 1893. This bulky volume is made up of four parts. The first part contains a summary of the results and methods of irrigation on the great plains, with details of the various elements that more or less directly affect the work. Then follows a review of the progress of irrigation in the various states that practice it. Several papers accompany these reports, touching special localities and special aspects of the problem, both in America and in the Old World. Between forty and fifty maps and illustrations are interspersed among the pages, showing the different methods adopted and the results obtained.

The second part is the final report of the chief engineer, Col. E. S. NETTLETON, on artesian and underflow investigations. It contains elaborate details on the engineering problems connected with the subject of artesian wells, the natural springs of the arid region, especially along the Coteaus, and the legislation touching the various questions that arise on this particularly western topic. It is illustrated with 28 profile maps and well records.

The third part contains the report of Prof. ROBERT HAY, in 39 pages, on the artesian and underflow investigations between the meridian of 97° and the foot-hills of the Rocky mountains. Here we find the geological details of the problem, so far as they pertain to the part of the work under discussion,—the water-bearing rocks of the plains, their elevation, the source of their supply in the mountains, the flow of the rivers, the extent of the artesian area, and the cause of flow.

The fourth part is Prof. R. T. HILL's report on the occurrence of artesian and other waters in Texas, New Mexico, and Indian Territory west of the 97th meridian. It contains a general account of the region and its geographic features, with discussions of the artesian conditions prevailing in the different portions. Nineteen sheets of illustrations, maps, and sections, accompany this paper, which fills 165 pages.

Following the above four parts, which alone are mentioned on the title page, comes a paper by Prof. L. E. HICKS on the underflow and the geological structure of Nebraska, and their effect on the water supply. A survey of the Loup valley is added, with especial regard to the hydrographic features. It occupies twenty pages, with five plates. There is also a paper by Prof. G. E. CULVER on the Dakota basin, in which the author treats of the artesian borings, with especial reference to the Black Hills water-supply. Appended is a preliminary geological map of the Dakotas and a section across South Dakota. Last come the reports of two special agents, Judge GREGORY and Mr. F. B. COFFIN. The former writes of the underwaters of the great plains, and the latter of certain artesian conditions existing in South Dakota.

It is not possible within the limits at our disposal to enter on anything

like a careful and detailed account of the contents of this volume. We can only dwell on a few points which will illustrate the nature, methods, and progress of the plans adopted for irrigating the arid region of the west. Mr. Hinton says (page 19):

"In the past seven years the actual area of reclamation by irrigation-cultivation has increased from about 5,000,000 to at least 8,500,000 acres. By the time of the opening of the Columbian World's Fair, the United States may expect the cultivation by means of irrigation of at least 17,000,000 acres of land that within the last decade have been declared by learned authority to be wholly irreclaimable, worthless for agriculture, useless for tree-planting, and hardly fit for even the grazing of scraggy sheep and the broad-horned steer."

"The removal of the alkali from the land is one of the first requirements. This is to be accomplished by underdrainage wherever the soil allows it. To flood the land till underdrains laid reasonable distances apart shall have run for some time will end the trouble, not only for the time being, but for centuries, provided only that solid beds of the alkali salts do not underlie it. But this is the rare exception."

In those parts of the arid region which can be irrigated the streams flow underground. These subterranean rivers exist in other parts of the country, but where water is abundant no effort is made to trace them. The Rio Santa Cruz in Arizona is an example of these. In the upper part of its course the stream is of varying width and depth, according to the season. Lower down it disappears altogether, but its course is marked by mesquite trees to a width of from 500 to 2,000 feet. The gravel of the valley has been tested at Tucson to a depth of 52 feet, and is estimated to carry 370,000 irrigating inches every twenty-four hours (page 75).

The various devices by which the hidden water is brought to light are explained. Of course when a pump is required, as is often the case, the work is expensive. But in those parts where the water is truly artesian, or even where it rises to the surface, little or no expense attends getting it except the sinking of the well.

The report of Col. Nettleton consists of a rapid survey along eleven lines across the country on the Platte and the Arkansas rivers and in the valley of the Loup, with an examination of the existing wells, in order to ascertain the probability of getting water by boring. Some curious statements are given regarding the so-called blowing wells, which in certain states of the weather emit a blast of air and in others suck air down the bore. On one of these he tells us that a brass whistle has been set which announces a coming storm with a note audible a quarter of a mile from the well.

Col. Nettleton made some attempt to ascertain the rate of flow of the underground water, but without success. He is, however, inclined to accept the figures of the French engineers and set it down at about one mile in the year or fourteen feet per day.

One of the strongest flows mentioned is in Beadle county, South Dakota. At 960 feet water was reached with pressure sufficient to furnish

100 horse-power, and in quantity enough to flood a twenty-acre field six inches deep in twenty-four hours. Many pages are occupied with similar details, indicating a simply enormous supply of artesian water in South Dakota at a depth less than 1,000 feet. The water is found in the Dakota sandstone, which outcrops along the eastern flanks of the Black Hills. The supply therefore enters the stratum along that outcrop, and doubtless also on the western border of the plains. Analysis shows that it is a permanently hard water, as might be expected, containing in a gallon fourteen grains of sulphate of lime, four grains of carbonate of lime, and five grains of magnesic carbonate.

In the third paper, Prof. Hay says that the same Dakota sandstone is the water-bearing formation in the Arkansas valley, and that it obtains some reënforcement from the underlying Jurassic strata. Both crop out around the Black Hills and in the upper Missouri river region. They allow water to pass through them very freely, as is shown by the Giant spring described by Lewis and Clark eighty years ago and still flowing as in their day, with an estimated yield of one hundred cubic feet a second or nearly 50,000 gallons a minute.

The great water-bearing stratum of large portions of the plains is a Miocene grit of an exceedingly absorbent nature, underlying extensive lacustrine beds of marly silt. At least half of the rainfall, or five inches yearly, is estimated by Prof. Hay to sink into the ground and to be held chiefly in this grit, from which it flows forth in copious springs along the river banks, wherever these have been cut down low enough to expose the grit. Water is also found in wells when sunk to its level, at the depth of from 50 to 300 feet below the general surface. Prof. Hay points out that these artesian waters are not derived from the mountains for the most part, because that source of supply is almost entirely cut off by the outcrop of the water-bearing stratum before it reaches the mountains.

The importance of the water problem is forcibly stated by Prof. Hill in the fourth part of this volume, where he says:

"In the western half of the United States the water question is not only serious but paramount to every other consideration, for there are vast areas, as large as all New England, such as the great Llano Estacado, without a single brooklet, river, or permanent pond upon the surface; while there are other areas, aggregating one tenth of the Union, which together do not possess a stream of the volume of the Connecticut or Mohawk, and are utterly lacking in the accompaniments of frequent laterals and springs. Great railway lines—the Southern Pacific for example—are obliged to haul water hundreds of miles for their engines, and have spent millions in not always judicious experiments to obtain an underground supply."

The Llano Estacado is described as one of the most remarkable geological features of the continent,—an area of 50,000 square miles, lying more than one thousand feet above the sea, and surrounded with a precipitous rampart which is gashed here and there by river valleys cut out of the nearly level strata of late Miocene or Pliocene date. No water

occurs on its surface, and we note that Prof. Hill takes a rather conservative view and speaks cautiously in regard to the existence of artesian conditions generally in the Llano. He says: "That the underground water-sheet of the Llano beds can be struck throughout the extent of the mesa has been demonstrated. But it is also apparent that since this water occurs in a surface formation—the Llano beds—there can be no hydrostatic pressure to force a surface flow. But there are other strata underlying portions of the Llano, beneath the Llano water-sheet, and to these we have cause to look with much hope that they may present favorable artesian conditions. . . . . . . Without committing myself to prophecy, it is my opinion that, when the portion of the Llano along the Texas-New Mexico line is thoroughly prospected, somewhere in that region will be found an abundant artesian supply from the underlying Dakota and Trinity sands."

In regard to the Trans-Pecos region, in spite of the unpromising aspect of this high plain, Prof. Hill speaks much more confidently of the existence of water at a moderate depth, about 200 feet, which, however, does not rise to the surface and therefore is not artesian, except in certain districts. Agriculture may therefore be possible to a limited extent there.

Space forbids following Prof. Hill into the question of the water-supply of the mountains, or Prof. Hicks into that of Nebraska. The same may be said of Prof. Culver's work on the Black Hills. There can be little doubt that continued investigation and adventure will gradually extend the cultivable lands of the west far into what was formerly called the Great American Desert, and that many thousand square miles will be reclaimed. There will, however, probably always remain large areas whose reclamation would cost more than they could ever repay. Farming will press hard on the possibility of subsistence, and occasional series of very dry seasons will from time to time set back the surging tide of immigration with their "Thus far but no farther."

E. W. C.

The Colorado Formation and its Invertebrate Fauna. By T. W. STANTON. U. S. Geol. Survey, Bulletin 106; 288 pages, 45 plates, 1893. The formation here described comprises the Fort Benton and Niobrara divisions of the Cretaceous series made known by Meek and Hayden in the upper Missouri region. Only some 25 or 30 species of invertebrates had been definitely assigned to it previous to Mr. Stanton's collections, chiefly in 1890, of the fossils of Huerfano park and adjacent localities in southern Colorado. These collections, and their comparison with equivalent beds in other parts of the United States, bring the total known invertebrate fauna of the Colorado formation up to about 150 species, including 39 that are believed to be new. The fauna as a whole is regarded as the approximate taxonomic equivalent of the Turonian in Europe.

W. U.

A Geological Reconnoissance in central Washington. By I. C. RUSSELL. U. S. Geol. Survey, Bulletin 108; 108 pages, 12 plates, 8 figures in the text, 1893. This exploration was undertaken for the purpose of ascer-

taining whether artesian water can be obtained for irrigation in the arid region through which the Columbia river flows east of the Cascade mountains. The area traversed embraces about 10,000 square miles. It is in large part occupied by the great Columbia lava flows, which reach thence far southward and eastward, having probably an average depth of about 2,000 feet upon fully 200,000 square miles. Associated with this formation is the John Day system of unconsolidated sand, clay, lapilli and volcanic dust, which attains a maximum thickness of more than 1,000 feet. Fossil leaves of ten species from the John Day strata near Ellensburg, Wash., are regarded by Mr. F. H. Knowlton as of Upper Miocene age. Seven of these species have also been obtained from the Auriferous gravels of California. After the deposition of the John Day system, the rocks of this area and of a vast region southward were divided by many fractures, sometimes scores of miles in length, and the resulting blocks were tilted, with displacements of 2,000 to 3,000 feet along many of the faults. In a few instances the enclosed valleys form artesian basins, but mainly the conditions of the geologic structure are found to be unfavorable for obtaining artesian water. W. U.

The Work and Scope of the Geological Survey. By C. R. KEYES. (Iowa Geol. Survey, Vol. III, Ann. Rept. for 1893, pp. 47-98, pls. 1-6, 1894.) During the short time that the Iowa Geological Survey has been in operation, two reports have been issued,* and the present paper is an extract from the third, which will be distributed shortly. The survey is organized on a practical and economic basis, but at the same time it is intended to be systematic and scientific,—the aim being to make a complete economic and geological survey of the state. The publications will be of a single series, uniform in size and general style, and will contain about 500 pages each. The unit of mapping will be the county; as the counties of Iowa are approximately of the same shape and area, the adoption of this unit will prove to be very convenient for a series of uniform maps. Among the results already accomplished, it may be stated that coal deposits have been investigated in fifty counties, clay industries in fifty-six, artesian and deep wells in forty-four; the mapping of seven couties is practically completed, while in eleven others the mapping is partially done. It is to be hoped that the next legislature will see fit to make it possible for the work, already so well under way, to be pushed more rapidly than the present appropriation allows.

U. S. G.

A Summary of Progress in Mineralogy and Petrography in 1893. By W. S. BAYLEY. Geological department, Colby University, Waterville, Me., 1894; price, 50 cents. In this pamphlet of about sixty pages are collected the various notes which the author has published in the *American Naturalist* during the last year. They consist in brief notices, abstracts and reviews of work in mineralogy and petrography. An index of authors and one of subjects furnish easy reference to the work of any individual or to that on any particular subject. U. S. G.

* Reviewed in the AMERICAN GEOLOGIST, vol. xii, p. 337; and vol. xiii, p. 353.

An Orbicular Granite from Quonochontogue Beach, Rhode Island. By J. F. KEMP. Trans. N. Y. Acad. Sci., vol. 13, pp. 140-144, pl. 2, 1894. The normal rock is a biotite granite in which are more basic spheroids two or three inches across and of rudely elliptical outline. The center of each spheroid consists almost entirely of plagioclase; toward the rim, biotite becomes noticeable and the spheroid is more finely crystalline; further out, the biotite assumes a concentric arrangement. After a very decidedly darker zone, the inner part of the spheroid ceases abruptly; outside of this is a zone, one-eighth to one-half inch wide, formed of plagioclase crystals with their twin lamellæ radiating from the inner portion. The specimen is from a boulder which the author thinks has not been moved far from its parent ledge. U. S. G.

On Argyrodite and a new Sulphostannate of Silver from Bolivia. By S. L. PENFIELD. (Amer. Jour. Sci., 3, vol. 47, pp. 451-454, June, 1894.) The new mineral is isometric and is almost identical with argyrodite in all of its physical properties; the formula is $Ag_8(SnGe)S_6$. Less than a year ago Prof. Penfield described as canfieldite a mineral of the same composition as argyrodite, but isometric instead of monoclinic. Since then the latter has been found to be isometric, so the name canfieldite is withdrawn and applied to this new species,—a sulphostannate of silver isomorphous with argyrodite. U. S. G.

The Ejected Blocks of Monte Somma. By H. J. JOHNSTON-LAVIS, Professor of Vulcanology, University of Naples. (Trans. Edinburgh Geol. Soc., vol. VI, pt. 5, pp. 314-351, pls. 13-15, 1893.) This is the first of an intended series of papers on these ejected blocks, the minerals of which, both for their beauty and variety, have made the region of Vesuvius so well known to mineralogists. The present paper deals with the alterations (metamorphism) to which the blocks of stratified limestone have been subjected. There are three stages in the degree of metamorphism: (1) carbonized limestone, (2) saccharoidal limestone with peridote, and (3) limestone nearly or entirely replaced by different silicates, sulphides, and fluorides. Briefly summed up, the changes are: first, the carbonization of the bituminous contents and their conversion into graphite, almost coincident with which recrystallization takes place; the recrystallization seems to have gone on without the rock having been fused, as delicate stratification, banding, faulting and contortion structure is preserved; at this stage a few grains of peridote appear; with the disappearance of the graphite, what remains is a more or less coarse-grained, dazzling white, saccharoidal marble; this saccharoidal marble, containing more or less peridote, passes somewhat abruptly into a mass of peridote and white pyroxene, wollastonite, or biotite. U. S. G.

Trenne nyupptäckta svenska klotgraniter. By HELGE BACKSTROM. (Geologiska Föreningens i Stockholm Förhandlingar, No. 156, Bd. 16, Häfte 2, pp. 107-130. Feb., 1894. With a German résumé.) Two new spheroidal granites, at present known only in loose blocks, are described from Kortfors and Balungstrand, in central Sweden. The first (Kortfors) consists of dark, well rounded, concentrically built spheroids in a sparse

groundmass of hornblende granite. The spheroids are more basic than the groundmass. They contain four zones, the first or outer of which is characterized by magnetite grains in a mass of oligoclase; the second has hornblende and biotite in large amount and oligoclase; the third is the broadest and consists of radially arranged oligoclase with small amounts of quartz and orthoclase; the center is almost free from dark minerals and is essentially quartz and orthoclase. The second type (from Balungstrand) has a coarse groundmass of microcline and quartz and some idiomorphic biotite. The spheroids are characterized by large oligoclase crystals; toward the periphery biotite is common, and the center is composed of microcline and quartz. Some remarks follow on the formation of the spheroids, especially in reference to the liquation theory of differentiating magmas. U. S. G.

The Rensselaer Grit Plateau in New York. By T. Nelson Dale. (Thirteenth Annual Report, U. S. Geol. Survey, pp. 291-340, pls. 97-101, 1894.) In this paper the geology of the eastern and central parts of Rensselaer county, N. Y., is discussed. The author's interpretation of the general structure of the region is given in a section from Mt. Greylock in Massachusetts, on the east, to the Hudson valley at Poestenkill on the west. The broad limestone (Stockbridge) belt west of Mt. Greylock dips westward under the Taconic range, which here is a synclinal, with two anticlinals, composed of a thickness of about 2,000 feet of Berkshire schists. The limestone again comes to the surface in the Berlin-Stephenson valley, on whose west side it dips under a small thickness of the Berkshire schists which are overlain by the Rensselaer grits; these extend westward for about ten miles, when the Hudson River shales (the equivalent of the Berkshire schists) emerge from beneath them. The Stockbridge limestone is stated to be Cambro-Silurian in age, and the Berkshire schists Lower Silurian (Hudson River). The Rensselaer grit occupies a plateau area, about 175 square miles in extent, in central Rensselaer county. The plateau is composed of grits with interbedded conglomerates and schistose and slaty rocks. In structure it consists of a well marked synclinal along its east side, a compound synclinal along its west side, and certainly one and probably several folds in the intervening area. Fossils to determine the age of the rocks of this plateau have not been found, but, on account of the areal relations of the grit to the Stockbridge limestone and the evidence of an unconformity of portions of the grit mass to Cambrian if not to Lower Silurian rocks, as shown by its pebbles, the grit is thought to be unconformable on the Berkshire schists and is considered to represent the Oneida conglomerate—the base of the Upper Silurian.

Mr. Dale's paper is of special interest in giving the structure and geographic distribution of the rocks of the Taconic range along the Massachusetts-New York line, and in giving details as to lithology and probable age of the Rensselaer grit rocks. However, there are some important points, especially in the stratigraphy, which it seems are not fully established, or are simply assumed from insufficient evidence; we have reference to the age of the Stockbridge limestone and the Berkshire

schists. It is to be noted that under the term Stockbridge he has included the Stockbridge proper and the western belt known as the Sparry limestone; that the two limestones are the same is evidently an assumption. Numerous Lower Silurian fossils have been found in the western belt, but in the Stockbridge proper we know of none but Lower Cambrian fossils. Moreover, it seems rather peculiar that one continuous limestone should represent all the accumulation in this region from the Lower Cambrian up to the Hudson River, while not far distant there is known to be a great thickness of other fossiliferous rocks between these two horizons. Again, Mr. Dale's idea allows no place for the unconformity which seems to exist at the base of the Potsdam. It, however, must be admitted that his work in the Vermont valley,* in connection with that of Dr. J. E. Wolff,† points to the Cambro-Silurian age of the Stockbridge limestone; still, it seems probable that an explanation differing from that of Mr. Dale's can be applied to the relations of the Lower Cambrian and the Lower Silurian limestones in the Rutland region. The Silurian age of that part of the Berkshire schists adjoining the Stockbridge proper does not seem to be established by fossils, and it is not at all improbable, in fact it seems very probable, that at least some parts of these schists are of the same age as the great thickness of Cambrian schists and slates not far to the north in Vermont.

The placing of the Rensselaer grit at the base of the Upper Silurian adds another feature of complexity to the original Taconic region. Mr. Walcott's map, published in 1888,‡ makes all of the area mapped by Mr. Dale as Rensselaer grit Lower Cambrian (Georgian), and now this grit series is placed in the Upper Silurian on no evidence derived from fossils, and that, too, in a region in which the deciphering of the structural geology is an extremely difficult task. N. H. W.

RECENT PUBLICATIONS.

Foreign.

Records of the Geological Survey of New South Wales, Vol. 3, Pt. 1, 1893, contains: On a sand from Bingera, G. W. Card; On the occurrence of *Trigonia semiundulata* M'Coy, in New South Wales, and its significance, R. Etheridge; On the occurrence of basalt-glass (tachylyte) at Bulladelah, G. A. Stonier; On palatal remains of *Palorchestes azael* Owen, from the Wellington Caves bone-deposits, W. S. Dun; Mineralogical and petrological notes, No. 1, G. W. Card; Note on an aboriginal skull from a cave at Bungonia, R. Etheridge; The Australian geological record for the year 1892, with addenda for the year 1891, R. Etheridge; A locality index to the Reports of the Geological Survey of

*On the structure and age of the Stockbridge limestone in the Vermont valley; Bul. Geol. Soc. Amer., vol. III, pp. 514-518, 1892.

†On the Lower Cambrian age of the Stockbridge limestone; Ibid., vol. II, pp. 331-338, 1891.

‡Amer. Jour. Sci., 3, vol. 35.

New South Wales, from 1875 to 1892 inclusive, W. S. Dun; On the occurrence of *Lepidodendron australe* (?) in the Devonian rocks of New South Wales, T. W. E. David; On celestine from the neighborhood of Bourke, G. W. Card.

Zeitschrift für praktische Geologie, Dec., 1893, contains: Was kann das Studium der dynamischen Geologie im praktischen Leben nützen, besonders in der Berufsthätigkeit des Bauingenieurs?, F. M. Stappf; Beiträge zur Erzlagerstättenkunde des Harzes, F. Klockmann; Die wahrscheinlichen Resultate einer Tiefbohrung in Lemberg (Galizien), R. Zuber.

Descriptions of two new species of Ammonites from the Cretaceous rocks of the Queen Charlotte Islands. By J. F. Whiteaves. Reprinted from the Canadian Record of Science, Oct., 1893.

The south-west Mayo and north-west Galway Silurian basin, with notes on the old or metamorphosed rocks of West Galway. By G. H. Kinahan. Trans. Edinburgh Geol. Society, Vol. 6, pp. 155-170. 1892.

Jahresbericht des Vereins für Erdkunde zu Dresden, XXIII, 1893, contains: Ueber Aktinitäts-Vergleichungen an verschiedenen Orten der Erde, Herman Krone.

Bulletin de la Société des Sciences Naturelles de L'Ouest de la France, Tome 3. No. 3, 1893, contains: Sur la présence de l' azurite dans l' argile de la Ville-au-Vay, près le Pellerin (Loire-Inf.); Nouveau gisement de grenat avec staurotide, Ch. Baret; Esquisse géologique de la Basse-Normandie, A. Bigot.

Bihang till Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band 18, Afd. 2, contains: Studier öfver Baltiska Hafvets Qvartära Historia, Henr. Munthe. Band 18, Afd. 3, contains Växtpaleontologiska Undersökningar af Svenska Torfmossar, Gunnar Andersson. Band 18, Afd. 4, contains: Ueber einige Ober-Silurische Cirripeden aus Gotland, C. W. S. Aurivillus.

Zur Frage der Structurformeln der metasomatischen Zersetzungsproducte. R. Scharizer; Zeitschrift f. Krystallographie, etc., XXII, 4, pp. 369-375, 1893.

Ueber den Unterschied zwischen der petrographischen und der geologischen Classification der Gesteine, J. v. Szabó: Verhand. d. Gesells. Deutscher Naturf. u. Aertze, 1891, 5 pages.

Verzeichnis der mineralogischen, geognostischen, ur-(vor-)geschichtlichen und balneographischen Literatur von Baden, Württemberg, Hohenzollern und einigen angrenzenden Gegenden, Heinrich Eck: Mitteilungen d. grossherzoglich badischen geol. Landesanstalt, 1 Erganzung zum 1 Bande, pp. 1-303, 1893.

Zeitschrift für praktische Geologie, Jan., 1894, contains: Die geologische Untersuchung des Königreichs Bayern, A. Leppla: Die geologische Landesuntersuchung von Elsass-Lothringen, L. van Werveke: Aphorismen über Zinnober, A. Schrauf: Die Kupfererzlagerstätten der Serpentingesteine Toscanas und deren Bildung durch Differentiationsprocesse in basischen Eruptivmagmen, B. Lotti: Die Bodensenkungen in Schneidemühl, W. Krebs: Die Bodensenkungen in Schneidemühl und

die daraus zu ziehende Nutzanwendung, R. Wabner: Erdwachsbergbau bei Boryslaw in Galizien; Vulcanische Asche aus Puerto Montt, F. M. Stapff: Stein- und Braunkohlen in Holland; Schneidemühl, R. Wabner: Schwefelbildung, C. Ochsenius.

Zeitschrift für praktische Geologie, Feb., 1894, contains: Ueber die Kieslagerstätten vom Typus Röros, Vigsnäs, Sulitelma in Norwegen und Rammelsberg in Deutschland (I. Die Mineralogie der Kieslagerstätten vom Typus Rorös-Rammelsberg), J. H. L. Vogt; Das Vorkommen der devonischen Eisen- und Manganerze in Nassau, W. Riemann; Bodensenkungen in Eisleben, W. Ule; Löslichkeit des Goldes, F. M. Stapff.

Das Erdbeben in der Gegend zwischen Strassburg, Forbach, Haslack, Kenzingen, Erstein und Westhofen am 11 Juni, 1887, H. Eck; 19 pages; Stuttgart, 1892.

The Crinoidea of Gotland, Part I.—The Crinoidea Inadunata. By F. A. Bather. Kongl. Svenska Vetenskaps-Akademiens Handlingar, B. 25, No. 2, pp. 1-200, 10 plates; Stockholn, 1893.

Bulletin de la Société Impériale des Naturalistes de Moscou, 1893, Nos. 2 and 3 contain: Die tithonischen Ablagerungen von Theodosia, Ein Beitrag zur Paleontologie der Krim (6 plates), O. Retowski; A la mémoire de feu J. D. Czersky, Al. Iwanowski.

Geologiska Föreningens i Stockholn Förhandlingar, No. 152, Bd. 15, Haft. 5, May, 1893, contains: Mineralogiska meddelanden, L. J. Igelström; Om Litorinatidens klimat och vegetation, R. Sernander; Om strandliniens förskjutning vid våra insjöar, G. De Geer; Mineralanalytiskt, O. A. Sjöström.

No. 153, Bd. 15, Haft. 6, contains: Om stoftfallet i Sverige och angränsande länder den 3 maj 1892, A. E. Nordenskiöld; Spodiosit från Nordmarken, G. Nordenskiöld; Tillägg till uppsatsen "om några mineral från grönland," G. Flink; Mineralogiska meddelanden.—Nya mineral från Sjögrufvan, L. J. Igelström; Några jemförelser mellan Sveriges och utlandets jernmalmslager med hänsyn till deras genesis, H. Sjögren; Om en profil från skredet i Værdalen, A. Hamberg.

No. 154, Bd. 15, Haft. 7, Dec., 1893, contains: Om en fossiliförande leraflagring vid Skattmansö i Upland, A. G. Nathorst; Pyrochlor från Alnön, P. J. Holmqvist; Om en kromhaltig vesuvian från Ural, Sofia Rudbeck; Om Falu grufvas geologi, A. E. Törnebohm; Meddelanden från Lunds Geologiska Fältklubb, 1.—Iakttagelser från gemensamma excursioner i Fågelsångstrakten, K. O. Segerberg.

The Geological Magazine, Feb., 1894, contains: Coral in the "Dolomites" of S. Tyrol, Miss M. M. Ogilvie; On some Jurassic species of Cheilostomata, J. W. Gregory; Notes on the composition of clays, slates, etc., and on some points in their metamorphism, W. M. Hutchings; On a tooth of Oxyrhina from the Red Crag of Suffolk, A. S. Woodward; An ancient glacial shore, T. M. Reade; Post-Glacial man in Britain, Wm. Shone; The horizon of the mammoth, Mark Stirrup; Action of glaciers, Wm. Churchill; The submarine crust, O. Fisher.

The Geological Magazine, March, 1894, contains: Four theories of

the age and origin of the Dartmoor granites. A. R. Hunt: Certain fossils from the lower Paleozoic rocks of Yorkshire. S. H. Reynolds: The rape of the chlorites. C. A. McMahon: Some notes on gneiss. T. G. Bonney: Notes on the Skiddaw slates. J. E. Marr: Rapid elevations, a self criticism. E. Hill.

The Glacialists' Magazine, vol. 1, no. 6, Jan., 1894, contains: On the glacial sands and gravels at Heck station, Yorkshire. C. E. De Rance: The great submergence. Joseph Lomas: Theories of the cause of the Glacial period: Current glacial bibliography: A typical fjord-valley: Prof. A. Krassnow, of Charkow, on his journey to the island of Saghalien: Icelandic glaciers: Pressure of the Rhone glacier. Marshall-Hall.

CORRESPONDENCE.

A Reply to some Statements in Professor Tarr's "Lake Cayuga a Rock Basin."* Under the title "Lake Cayuga a Rock Basin," Prof. Ralph S. Tarr, of the geological department of Cornell University, presented a paper before the Boston meeting of the Geological Society of America (December 29, 1893), which has since been issued in its printed form. In this paper he has quoted from an early publication of mine, and, by the selection of a few sentences apart from their context, has placed a misconstruction upon my work which I am unwilling to let pass without correction.

The field work upon which my little article "The Geology of Itasca, New York, and the Vicinity;"† was based, was that of a college undergraduate, having been done during the winter and spring terms of 1874-75 in the preparation of a thesis for graduation at Cornell University. I do not offer this as any excuse whatever for the conclusions reached, for I am still willing to be judged by them, but to emphasize the fact that, after twenty years of progress in the study of glacial phenomena, it would, indeed, be surprising should different interpretations not be placed upon the same data. That my views, as then expressed, were in accord with "the modern school of glacial geology," will, I think, be apparent to those who read understandingly what I said upon the subject.

My thesis opened with a general account of the topography of the region about Ithaca, incidentally mentioning Cayuga lake, but was mainly devoted to the consideration of "Special Features on Six Mile creek." That it was well thought of by the Faculty is attested by the award of the "President's First Prize in Geology." Later, I was requested to select from it a portion of general interest for presentation to the public on Commencement day, and this paper, in substance, was sent to the American Naturalist, appearing in the issue of that magazine

*Bulletin of the Geological Society of America, vol. v, pp. 339-356, March, 1894

†The American Naturalist, vol. xi, pp. 49-51, January, 1877.

for January, 1877, and from it Prof. Tarr has drawn certain conclusions. What he has quoted and his comments, under the caption, "Reviews of Opinions of previous Writers," are as follows:

"Simonds shows that there are in this region two classes of valleys—gorges, 'true valleys of erosion,' and rounded, smoothed valleys. Of the latter he says:

"'Noting in addition [to their even slope] the depth at which the water flows and the small number of cascades and waterfalls, the conclusion is at once reached that these valleys have been acted upon by some agency not now in operation.'

"He can easily understand the gorges, but cannot explain the broad valleys by erosion, and therefore concludes that 'these deep, well-worn valleys are undoubtedly the work of glacial action.' According to this author the glacier divided near the present site of Ithaca, one lobe moving southward, the other carving out Six Mile creek.

"This, which seems to be the first statement of the glacial origin of Cayuga valley, is based upon the inability of the author to conceive of the formation of a broad, deep valley by river erosion and transportation. It seems strange that he should not have noticed that this valley was but one of a type which exists in that region with directions varying through all degrees of the compass, and hence, that all are not capable of explanation by glacial erosion."*

Again, under the caption, "Observations and Interpretations," he says:

"*Evidence of Six Mile creek.*—At the head of the lake, in the city of Ithaca, the valley divides—one part, known as the Inlet valley, continues southwestwardly and then southerly; the other, called Six Mile creek valley, extending in a southeastern direction. The latter is evidently a tributary to the former, which was the preglacial main valley. These two valleys are the ones which Simonds and Foote believe to be due to ice action. They are both distinctly preglacial in form and are joined by mature tributaries."†

What I did say upon the subject of valleys was as follows:

"At Ithaca there are two distinct types of river or creek valleys—the one with rounded and well-worn sides, the other bordered by precipitous walls of rock. To the latter class belong Cascadilla and Fall creeks, which flow into the Ithaca plain from the east. Their valleys are true valleys of erosion, having been formed since the withdrawal of the vast ice-sheet which swept over this portion of North America in Quaternary time. With the exception of Six Mile creek valley and that of Cayuga Inlet, which open into the lake basin from the southeast and south respectively, all the streams of this immediate vicinity flow through deep cuts or cañons, in which they descend by numerous cascades and water-falls to the lake. As their valleys are mere chasms, they make no appreciable change in the general contour of the land. With valleys of the first type, however, the effect is of an entirely different char-

*Bulletin, G. S. A., vol. v, p. 344.
†Bulletin, G. S. A., vol. v, p. 350.

acter. They are distinctly marked. Their longer slope and greater width make a prominent feature in the topography of Ithaca. Noting in addition the depth at which the water flows, and the small number of cascades and water-falls, the conclusion is at once reached that these valleys had been acted upon by some agency not now in operation. We can observe changes going on in Fall and Cascadilla creeks: we can easily understand how their deep, rocky cañons could be formed and are still being formed by the action of water and frost upon shale, and we can readily see that the conditions which obtained in the formation of these valleys could never explain the deep, well-marked valleys of Six Mile creek and the Cayuga Inlet, with their sloping banks and knolls and terraces. These deep, well-worn valleys are undoubtedly the result of glacial action. The mass of ice which filled the Cayuga lake basin, dividing at its southern extremity, one part—the larger—flowed to the south, wearing down the Inlet valley, and the other traversed the Six Mile creek valley, both of which were occupied by preglacial streams. The scratches on the polished surface of the underlying rocky table, as seen at the quarry in front of the buildings of the Cornell University, on the eastern edge of the basin, indicate that the glacier followed a direction a little east of south, corresponding with that of the lake. Among the drift accumulations are found bowlders of Oriskany sandstone, and masses of Hamilton shale, formations which occur to the north, together with small granitic bowlders. The valley of Six Mile creek furnishes some special examples of the drift phenomena. In several places its old channel has been completely choked up with masses of morainic débris about which the present stream has been obliged to cut its way through deep cañons."*

In his comments Prof. Tarr says:

[1.] "He (Simonds) can easily understand the gorges, but cannot explain the broad valleys by erosion, and therefore concludes that 'these deep, well-worn valleys are undoubtedly the result of glacial action.'"

As will be seen, in the extract from my article given above, I reached my conclusion not only for the reason "that the conditions which obtained in the formation of these valleys [Fall and Cascadilla creeks] could never explain the deep, well-marked valleys of Six Mile creek and Cayuga Inlet," but for other reasons. Thus I distinctly stated that "the valley of Six Mile creek furnishes some special examples of the drift phenomena. In several places its old channel has been completely choked up with masses of morainic débris about which the present stream has been obliged to cut its way through deep cañons." Hence my conclusion, in this instance at least, was based upon the actual occurrence of morainic matter, with *glaciation as the legitimate inference.*

As a matter of fact, the presence of a glacier cannot be disputed: and if present, does Prof. Tarr, for an instant, believe that it could have forced its way through such a valley as that of the preglacial Six Mile creek, excavated as it must have been in the thin-bedded Chemung

*American Naturalist, vol. XI, pp. 50-51.

rocks, without great abrasion? He says: "The north and south valley of lake Cayuga is several hundred feet below it [the rock bottom of Six Mile creek], and its depth has without doubt been caused by glacial erosion."* But what of the evidence furnished by "the scratches on the polished surface of the underlying rocky table, as seen at the quarry [1874-76] in front of the buildings of Cornell University," *several hundred feet above the present lake surface*?

Again, that the ice moved in a general southerly direction, up the Cayuga valley, into that portion of the basin which receives the modified valleys of Cayuga Inlet and Six Mile creek, is plainly indicated by the presence, among the drift accumulations, "of bowlders of Oriskany sandstone and masses of Hamilton shale, formations which occur to the north." And, further, I have a distinct recollection of collecting in my student days, *characteristic fossils of these formations from fragments found in the valley of Six Mile creek.*

[2.] "According to this author (Simonds), the glacier divided near the present site of Ithaca, one lobe moving southward, the other carving out the valley of Six Mile creek." What I did say, as shown above, was this: "The mass of ice which filled the Cayuga lake basin, dividing at its southern extremity, one part—the larger—flowed to the south, *wearing down* the Inlet valley, and the other traversed the Six Mile creek valley, *both of which were occupied by preglacial streams.*"

By this it will be plainly seen that I meant that the valleys were *moulded* by ice action, not "*carved*" in the sense that Prof. Tarr would have us understand. My idea was then and is now, that these preglacial valleys served to guide the ice-sheet as it advanced toward the south, and that by it they were broadened and worn, giving rise to their present characteristic and distinctive shapes.

[3.] "This, which seems to be the first statement of the glacial origin of Cayuga valley, is based upon the inability of the author [Simonds] to conceive of the formation of a broad, deep valley by river erosion and transportation." Rather, my statement was based upon the presence of striæ, not only in the locality mentioned, but in others; upon the presence of drift resting directly on a polished and worn surface; and upon the presence of masses of rock transported [by ice] from the north, i. e., brought up the valley.

[4.] Under "Evidence of Six Mile creek," we find that "these two valleys [Six Mile Creek and Cayuga Inlet] are the ones which Simonds and Foote believe to be due to ice action. They are both distinctly preglacial and are joined by mature tributaries." Concerning this I have only to say that I recognized their preglacial character and so expressed myself in my article by saying "both of which valleys were *occupied by preglacial streams.*" In the conclusion of the original thesis occurs the following significant statement: "Six Mile creek we have seen to be a preglacial stream whose channel has not only been traversed and worn out by ice, but in many places filled with morainic débris * * *."

*Bulletin, G. S. A., vol. v, p. 350.

After all, it is not surprising that Prof. Tarr should misunderstand me, for it appears from his own statement that, at the time Dr. D. F. Lincoln's paper, "Glaciation of the Finger-Lake Region of New York,"* was published, *he was so strongly convinced that the valleys were river valleys, unmodified by ice, that his [Lincoln's] paper produced no impression.* It was only when the clearness of the evidence impressed itself so forcibly on his mind that he could be but convinced that he again looked at his [Lincoln's] paper, and found that he had the same kind of proof. Therefore, although independently worked out, the facts in this article [Tarr's "*Lake Cayuga a Rock Basin*"] are merely confirmations of Dr. Lincoln's study and deductions.† FREDERIC W. SIMONDS.

University of Texas, Austin, April 12, 1894.

THE NIAGARA GORGE AS A MEASURE OF THE POSTGLACIAL PERIOD. In Nature for May 17th (vol. 50, p. 53) Mr. G. K. Gilbert expresses his doubt that the past rate of erosion of the gorge below the receding falls of Niagara can be so compared with the present rate as to afford any approximate measure of the time which has elapsed since the Ice age. His first study of this question (Proc. A. A. A. S., vol. xxxv, for 1886, pp. 222, 223) gave about 7,000 years for the erosion of the Niagara gorge, if it had proceeded with an average rate like the present. As this erosion began at the time of retreat of the ice-sheet from that area and has been in progress during all the subsequent time, it has been regarded as a geologic chronometer, like the similar erosion of the gorge below the falls of St. Anthony, from which Prof. N. H. Winchell had previously computed the length of the Postglacial period in Minnesota to be about 7,800 years.

The largest element of uncertainty (as hitherto supposed) in the estimate drawn from the rate of recession of Niagara falls is shown by Mr. Gilbert's later and more full discussion (Sixth Annual Report of the Commissioners of the State Reservation at Niagara, for the year 1889, pp. 61-84, with eight plates, also in the Smithsonian Annual Report for 1890) to consist in the probability or possibility that for some considerable time, next following the melting away of the ice upon the area crossed by the Niagara river, the outlet of lakes Superior, Michigan and Huron, may have passed to the St. Lawrence by a more northern course, flowing across the present watershed east of lake Nipissing to the Mattawa and Ottawa rivers. Since Mr. Gilbert's writing his recent communication to Nature, however, much new light on the Quaternary history of the great lakes tributary to the St. Lawrence river has been contributed in three papers by Mr. F. B. Taylor, published in the Bulletin of the Geological Society of America (vol. v, pp. 620-626, April 30, 1894),‡ and in the May and June numbers of the AMERICAN GEOLOGIST. Supplementing the earlier observations and studies of Whittlesey, Newberry, Gilbert, Spencer, Lawson, Chamberlin, Leverett, Claypole,

*Am. Jour. of Science, III, vol. XLIV, pp. 290-301, Oct. 1892. A later paper on this subject by Dr. Lincoln is in vol. XLVII, pp. 105-113, Feb., 1894.

†Bulletin G. S. A., vol. v, p. 348, foot-note.

‡Abstract in the March AM. GEOLOGIST, p. 220.

The Glacialists' Magazine,

A Monthly Magazine of Glacial Geology,

PUBLISHED IN LONDON: F. H. BUTLER, 158 BROMPTON ROAD, S. W.

COMMENCED AUGUST, 1893.

Edited by PERCY F. KENDALL, F. G. S.,

Lecturer on Geology at the Yorkshire College, and Secretary of the British Association Committee on Erratic Blocks.

ASSISTED BY

Warren Upham, F. G. S. A.,

Assistant on the Geological Surveys of New Hampshire, Minnesota, and the United States;

C. E. De Rance, F. G. S., F. R. G. S.,

Of H. M. Geol. Survey; President of the Glacialists' Assoc'n;

AND

J. Lomas, A. R. C. S.,

Special Lecturer in Geology at University College, Liverpool.

Subscription price, Five Shillings ($1.25) per year.

Postal Orders to be payable to the Treasurer,

R. T. HEYS, Stockport, England.

---

teorological explanation as follows: The melting of the vast western part of the ice-sheet in the United States, from North Dakota and Minnesota east to the lake Erie basin, would supply to our eastwardly moving storms a very great amount of moisture to be precipitated farther east. That precipitation I think to have been mainly snow as these storms, moisture-laden from the western ice-melting, swept over the more eastern part of the ice-sheet. Hence, the eastern great ice-lobe from Salamanca to Long Island, Cape Cod, and the Gulf of Maine, would be fed and fattened to be thick and spread in some places even beyond its previous limits, while all of the ice-sheet farther west in the United States was being melted away.

Another unforeseen conclusion, relative to the volume of the Niagara river while the ice-sheet was departing, is brought by our consideration of the uplift of the northern side of the glacial lake Warren, which along its extent of 600 miles from west to east was rapidly raised in general about 350 feet, as compared with the Chicago outlet, before the date of the Nipissing beach. This I think to be the first shore line formed in that northern area after the Chicago outlet ceased and after lake Warren was thereby succeeded by lake Algonquin in the basins of Michigan, Huron and Superior, while lake Iroquois then began to exist in the Ontario basin, outflowing by Rome, N. Y., to the Mohawk and Hudson. But this Nipissing beach, at the present lake level at Duluth, 25 feet above lake Superior at Houghton and Marquette, and 50 feet at the Sault Ste. Marie, rising to 140 feet above lake Superior or 743 feet above the sea at lake Nipissing, is so high, 50 feet upon a width of more than a mile, above the watershed east of that lake leading to the Mattawa and Ottawa rivers, that I cannot believe a river of such depth and width to have there outflowed. Instead, I believe that the ice-sheet then still remained as a barrier upon the Mattawa and Ottawa areas; and careful study of Prof. J. W. Spencer's maps in recent volumes of the Am. Jour. of Science (Dec., 1890; Jan. and March, 1891; March, 1894; also Bulletin, G. S. A., vol. II, pp. 465-476, April, 1891) of the Huron and Erie shore lines convinces me that the outflow of lake Algonquin at the time of the Nipissing beach went by way of the present St. Clair and Detroit rivers and along the bed of lake Erie to the incipient Niagara and lake Iroquois. Seven-eighths of all the uplifting of the Nipissing area which carried its watershed above the hight at which it could be an outlet of lake Algonquin had taken place before the Niagara river and lake Iroquois began to exist. Later, while yet the ice was a barrier on the Mattawa area, I believe that the continuation of that uplift fully raised the Nipissing-Mattawa divide above lake Algonquin, for meanwhile the lake Iroquois area was undergoing a large differential uplift of increasing amount from south to north. The Niagara river thus appears to have had a volume equal to the present during its entire history. If there was any time of diversion of the waters of the upper Laurentian lakes to the Mattawa valley, it was of very brief duration, and would require only an insignificant addition to the estimate of 7,000 years for the duration of the Niagara river and of the Postglacial period.

In a recent paper in the Journal of Geology (vol. II, p. 142, Feb.-March, 1894), Mr. Andrew M. Hansen, of Norway, notes the approximate concurrence of about thirty independent measurements, and estimates of the length of the Postglacial period which have been made in North America and in Europe, all coming within the limits of 5,000 and 12,000 years. He therefore says: "With full regard to a legitimate calculation of probabilities, it may be predicated that the number of 7,000 to 10,000 years is as nearly an exact estimate of the duration of postglacial time as can ever be expected." WARREN UPHAM.

June 11th, 1894.

P. S. Since the foregoing was written, I learn, by a letter of June 18th from Mr. Gilbert, that a narrower part (probably the original col) of the valley leading from lake Nipissing to the Ottawa is situated about ten miles east of the present water divide, where the Mattawa river, outflowing from Trout lake, is enclosed, near the mouth of that lake, by rocky hills. Mr. Gilbert also calls attention to the great depth of the Niagara river (having a maximum sounding of 185 feet) at the foot of the falls and for nearly two miles to the head of the Whirlpool rapids. The deep excavation there below the river level, analogous to pot-hole erosion, he attributes to a probably larger volume of the river than that which previously formed the shallower and longer portion of the gorge, excepting only at the Whirlpool, where the postglacial gorge coincides with one of preglacial age. Concerning the preglacial erosion along the course of the Niagara, Dr. Julius Pohlman has written in the Proc. A. A. A. S., vol. xxxv, for 1886, pp. 221, 222. The greater thickness of the Niagara limestone at and near the falls than along the part of the gorge beyond the Whirlpool may probably account chiefly for the deeper excavation by the cataract now than during the early part of its recession. W. U.

June 21st, 1894.

PERSONAL AND SCIENTIFIC NEWS.

THE GEOLOGICAL SOCIETY OF AMERICA will hold its sixth summer meeting in Brooklyn, N. Y., Aug. 13-15; and the American Association for the Advancement of Science will hold its forty-third meeting in the same city, Aug. 15-24. Several excursions for geologists are planned, affording opportunities to study the Palisades of the Hudson, the Cretaceous strata of New Jersey and of Staten and Long islands, and the terminal moraine of the ice-sheet.

AT A MEETING OF THE GEOLOGICAL SOCIETY OF FRANCE, May 7th, 1894, M. Cayeux presented a preliminary note on the radiolarians of the Pre-Cambrian of Bretagne. He finds that they belong to the divisions Spumellaria and Nassellaria, the latter

The A the classification of the radio-
terized by a complexity and a
e-existence of several other

Glacial Kettle-holes in Cana ge. Certain of these Pre-
time. A more complete
appear in the
provision
Survey,
ion of
Tai-

General description of these holes. **the physical** features of the vicinity. **ada: Lake Superior**: North Channel of lake-ill **northeast shore** of Georgian bay: Spanish, Wah. **the Ottawa valley.** Similar kettle-holes in Califo **way, Sweden, and** Finland. Occurrence at many d **Great size** and depth of some examples. Their occur and singly. Theories as to the general manner of their f planations of the mode of excavation. Bröggen's and Ren **Some** constant features as to their local surroundings. **which would** affect the ice of the glaciers at these localities. **sided recesses** in the face of steep rocks. Materials filling the h Geological data of their formation. Popular fallacies as to glacial k tle-holes. Illustrated by photographs, drawings and sketches.

On the occurrence of a large area of Nepheline Syenite in the townships of Dungannon and Faraday, eastern Ontario. FRANK D. ADAMS.

Description of the petrographical character or mode of occurrence of a large area of this rock discovered last summer in the Laurentian of eastern Ontario. The mass extends for a distance of over seven miles in an east and west direction and is in places exceedingly coarse in grain, nepheline individuals 2½ feet in diameter having been observed. Very large masses of sodalite have also been obtained. The rock presents many striking peculiarities of composition. The paper concludes with a reference to the few other localities in the world where this rock is known to occur.

On Nepheline Sodalite and Orthoclase from the Nepheline Syenite of Dungannon, Hastings county, Ontario. B. J. HARRINGTON.

This paper presents the results of a chemical examination of the nepheline and sodalite, as well as of a secondary orthoclase from the rock described in the last paper.

On some of the Cretaceous Fossils collected by Dr. (now Sir) James Hector, during Captain Palliser's Explorations in British North America, in 1857-60. J. F. WHITEAVES.

These fossils, which were kindly lent to the writer by the Geological Society of London, are partly from the Northwest Territories and partly from Vancouver Island. They were reported upon provisionally by Mr. Etheridge in 1861 and 1863, but the subsequent publication by Mr. Meek of his "Report on the Cretaceous and Tertiary Fossils of the Upper Missouri Country," and of an illustrated paper on the fossils of the Cretaceous rocks of Vancouver and the Sucia Islands, has enabled them to be determined with much more accuracy now than was possible then. Unfortunately, some of the fossils collected by Sir James Hector cannot now be found.

Notes on some Fossils from the Nanaimo formation of Vancouver, Hornby, and Denman islands. J. F. WHITEAVES.

The specimens referred to in this paper are the property of the Provincial Museum at Victoria, B. C., and were obligingly lent by its curator, Mr. John Fannin. Many of them were collected quite recently by Mr. Walter Harvey, of Comax. They include a *Gryphæa* not previously noticed in these rocks, remarkably fine and perfect examples of *Lytoceras jukesii* Sharpe, and other interesting ammonitoid forms, three of which are probably new; also three new species of decapod crustacea. Two of these crustacea are crabs, and the other a long-tailed lobster-like species, apparently referable to the genus *Podorates*.

black bituminous graptolitic shale ...etc., of the St. Lawrence and Hud-son river valleys whose position ...e scale of the geological formations of North America has rem... so long an unsettled problem. The ge-ographical distribution ...is formation throughout Canada and certain adjoining districts of ...e United States, its fauna and faunal relations, together with the ...aring of the facts obtained to date in support of the validity of Sir W...illiam Logan's "Quebec group," are also discussed. An attempt is ...ade to give this formation a resting-place in the lower portion of th... Ordovician of America.

The P...sdam and Calciferous formations in Quebec and east-...n Ontario. R. W. ELLS.

The paper describes the physical characters of these formations as originally understood, and their distribution in Ontario and Quebec. It indicates the intimate relation between the two, both from the strati-graphical and palæontological standpoints, and discusses the relation of the Podsdam sandstone to the underlying Cambrian and the propriety of assigning this formation to the base of the Cambro-Silurian (Ordovi-cian) system, rather than to the Cambrian.

Organic Remains of the Little River group. G. F. MATTHEW.

The first part is a brief review of the flora of this group as described by Sir Wm. Dawson. The flora as an entity is compared with the sev-eral floras ranging from the Upper Silurian to the Coal Measures that have been found in the Middle States and northeastern America. Sir Wm. Dawson's genera are used for this purpose. The genera based on fossil woods, chiefly from the middle division of the Devonian rocks, are not considered, as they were investigated with the microscope. Of the thirty-three genera of the Little River group, nine are found in the Lower Carboniferons, and an equal number in the Upper and Middle Devonian. respectively. On the other hand, the very remarkable fact is brought in view that there are no less than twenty genera of the Coal Measures. Yet it is quite certain that there was no direct or near con-nection between the flora of the Little River group and that of the Coal Measures, as will be seen from the data given in the former article on this group. The explanation of the large number of genera common to the two formations probably is that the Little River time and group an-ticipated the climate and soil of the Coal Measures in a way that did not happen in northeastern America in any of the times referred to earlier than the Coal Measures, so far as we know. The myriapods of the Lit-tle River group number six and are of five different genera. The most abundant fauna of a similar kind is that of the lower Coal Measures of Mazon creek, Illinois. Several of the genera found there occur in the plant bed of the Little River group. The most remarkable are those of the genus Euphoberia.

The Fossil Cockroaches of North America. S. H. SCUDDER.

Progress of Geological Investigation in southwestern Nova Scotia. L. W. BAILEY.

The only existing publications referring to the geology of southwest-ern Nova Scotia are the Arcadian Geology of Sir William Dawson and a report upon the gold fields of the province by Dr. A. R. C. Selwyn, 1871. In each of these cases the observations recorded were based upon cur-sory examinations only, and were for the most part confined to the sea-board. During the last three or four years a much more systematic ex-ploration of the region has been effected, under the auspices of the geological survey, and the purpose of the present paper is to give a summary of the results attained. The paper is accompanied by a sketch map showing the latest results in the delimitation of the formations represented.

Glacial Kettle-holes in Cana, in the classification of the radio-
General description of these hole cterized by a complexity and a
the physical features of the vicinity. existence of several other
ada: Lake Superior; North Channel of lake
northeast shore of Georgian bay; Spanish, Wah Certain of these Pre-
the Ottawa valley. Similar kettle-holes in Califo A more complete
way, Sweden, and Finland. Occurrence at many d. appear in the
Great size and depth of some examples. Their occur
and singly. Theories as to the general manner of their fo
planations of the mode of excavation. Bröggen's and Ren provision
Some constant features as to their local surroundings. Survey,
which would affect the ice of the glaciers at these localities. of
sided recesses in the face of steep rocks. Materials filling the h
Geological data of their formation. Popular fallacies as to glacial ket-
tle-holes. Illustrated by photographs, drawings and sketches.

On the occurrence of a large area of Nepheline Syenite in the townships of Dungannon and Faraday, eastern Ontario. FRANK D. ADAMS.

Description of the petrographical character or mode of occurrence of a large area of this rock discovered last summer in the Laurentian of eastern Ontario. The mass extends for a distance of over seven miles in an east and west direction and is in places exceedingly coarse in grain, nepheline individuals 2¼ feet in diameter having been observed. Very large masses of sodalite have also been obtained. The rock presents many striking peculiarities of composition. The paper concludes with a reference to the few other localities in the world where this rock is known to occur.

On Nepheline Sodalite and Orthoclase from the Nepheline Syenite of Dungannon, Hastings county, Ontario. B. J. HARRINGTON.

This paper presents the results of a chemical examination of the nepheline and sodalite, as well as of a secondary orthoclase from the rock described in the last paper.

On some of the Cretaceous Fossils collected by Dr. (now Sir) James Hector, during Captain Palliser's Explorations in British North America, in 1857-60. J. F. WHITEAVES.

These fossils, which were kindly lent to the writer by the Geological Society of London, are partly from the Northwest Territories and partly from Vancouver Island. They were reported upon provisionally by Mr. Etheridge in 1861 and 1863, but the subsequent publication by Mr. Meek of his "Report on the Cretaceous and Tertiary Fossils of the Upper Missouri Country," and of an illustrated paper on the fossils of the Cretaceous rocks of Vancouver and the Sucia Islands, has enabled them to be determined with much more accuracy now than was possible then. Unfortunately, some of the fossils collected by Sir James Hector cannot now be found.

Notes on some Fossils from the Nanaimo formation of Vancouver, Hornby, and Denman islands. J. F. WHITEAVES.

The specimens referred to in this paper are the property of the Provincial Museum at Victoria, B. C., and were obligingly lent by its curator, Mr. John Fannin. Many of them were collected quite recently by Mr. Walter Harvey, of Comox. They include a *Gryphæa* not previously noticed in these rocks, remarkably fine and perfect examples of *Lytoceras jukesii* Sharpe, and other interesting ammonitoid forms, three of which are probably new; also three new species of decapod crustacea. Two of these crustacea are crabs, and the other a long-tailed lobster-like species, apparently referable to the genus *Podocrates*.

Walker Prizes in Natural History.

By the provisions of the will of the late Dr. William Johnson Walker two prizes are annually offered by the BOSTON SOCIETY OF NATURAL HISTORY for the best memoirs written in the English language on subjects proposed by a committee appointed by the Council.

For the best memoir presented a prize of sixty dollars may be awarded; if, however, the memoir be one of marked merit, the amount may be increased to one hundred dollars, at the discretion of the committee.

For the next best memoir, a prize not exceeding fifty dollars may be awarded.

Prizes will not be awarded unless the memoirs presented are of adequate merit.

The competition for these prizes is not restricted, but open to all.

Each memoir must be accompanied by a sealed envelope enclosing the author's name and superscribed with a motto corresponding to one borne by the manuscript, and must be in the hands of the Secretary on or before April 1st of the year for which the prize is offered.

SUBJECTS FOR 1895:—

(1) A study of the "Fall line" in New Jersey.
(2) A study of the Devonian formation of the Ohio basin.
(3) Relations of the order Plantaginaceae.
(4) Experimental investigations in morphology or embryology.

SUBJECTS FOR 1896:—

(1) A study of the area of schistose or foliated rocks in the eastern United States.

(2) A study of the development of river valleys in some considerable area of folded or faulted Appalachian structure in Pennsylvania, Virginia, or Tennessee.

(3) An experimental study of the effects of close-fertilization in the case of some plant of short cycle.

(4) Contributions to our knowledge of the general morphology or the general physiology of any animal, except man.

NOTE.—In all cases the memoirs are to be based on a considerable body of original work, as well as on a general review of the literature of the subject.

SAMUEL HENSHAW,
Secretary.

Boston Society of Natural History,
Boston, Mass., U. S. A.

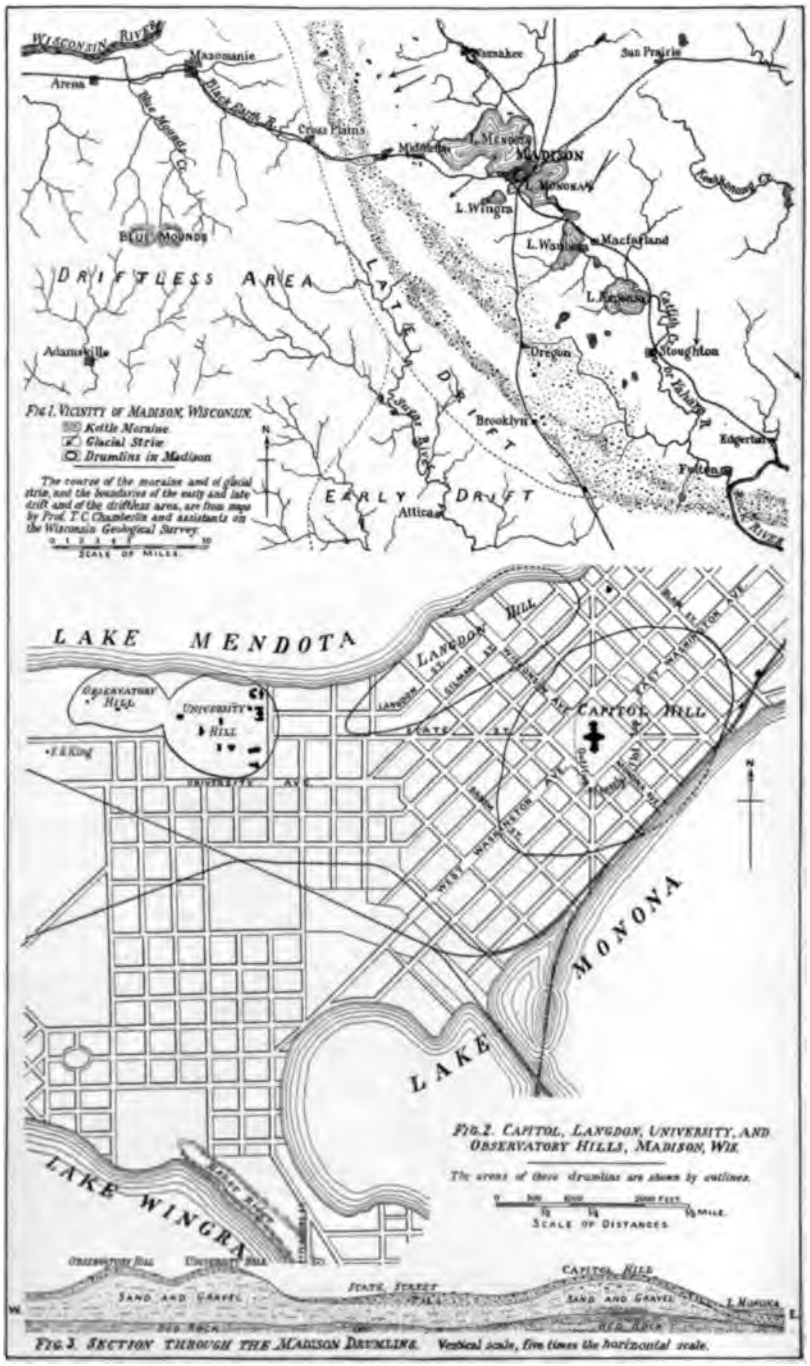


FIG. 1. VICINITY OF MADISON, WISCONSIN.

FIG. 2. CAPITOL, LANGDON, UNIVERSITY, AND OBSERVATORY HILLS, MADISON, WIS.

FIG. 3. SECTION THROUGH THE MADISON DRUMLINS. Vertical scale, five times the horizontal scale.

THE MADISON TYPE OF DRUMLINS.

THE

AMERICAN GEOLOGIST

VOL. XIV. AUGUST, 1894. No. 2.

THE MADISON TYPE OF DRUMLINS.*

By WARREN UPHAM, Somerville, Mass.

(PLATE III.)

CONTENTS.

DRUMLINS ENCLOSING NUCLEAL BEDS OF SAND AND GRAVEL, BUT MAINLY COMPOSED OF TILL, IN WINTHROP AND SCITUATE, MASS.

The earliest publications known to me of observations of drumlins structurally resembling those which form the subject of this paper are by Mr. W. W. Dodge, of Cambridge, Mass.,† and by the present writer,‡ describing the oval hills of till called Great Head in Winthrop and Third and Fourth Cliffs in Scituate, Mass., each of which is nearly half washed away by the sea. Great Head, having only a slight thickness of basal and nucleal stratified beds, is one extreme of a series. Its middle term is represented by the Third and Fourth Cliffs. Its most full and complete expression is found in the Capitol, University, and Observatory hills in Madison, Wisconsin, consisting chiefly of a nucleal mass of sand and gravel with a veneer of till, which I had opportunity to examine

*A paper presented before the Geological Society of America at the Boston meeting, Dec. 29, 1893.

†Am. Jour. of Science, third series, vol. XXXVI, p. 56, July, 1888.

‡Proceedings, Boston Society of Natural History, vol. XXIV, pp. 127-132, Dec. 19, 1888; and same vol., pp. 228-242, April 17, 1889.

during attendance at the last summer meeting of this society. We may best understand the structure and origin of this peculiar class or type of drumlins, here named the Madison type from the city where it is so finely displayed, by noticing in the foregoing order its several gradations of development.

Great Head, five miles northeast of Boston, is an excellent example of the many drumlins which form the islands of Boston harbor and abound in all the surrounding cities and towns to a distance of five to ten miles or more from the state house. Other examples are Beacon hill in Boston; Bunker hill in Charlestown; Prospect and Winter hills in Somerville; the Observatory hill in Cambridge; Corey hill in Brookline; Chestnut and Institute hills in Newton; Bellevue hill in West Roxbury; Mt. Bowdoin in Dorchester; the Wollaston Hights, Forbes, and President's hills, in Quincy; Great hill in Weymouth; Baker's and Prospect hills in Hingham; all the hills of the Nantasket peninsula; Scituate hill in Cohasset: and First, Second, Third, and Fourth Cliffs, in Scituate.

These drumlins, which were formerly known by Prof. C. H. Hitchcock's designation as lenticular hills of till or unmodified glacial drift, attain hights varying from 30 to 200 feet above their bases. Their crests in this district of Boston and its neighborhood adjoining Massachusetts bay are at all altitudes from very near the sea level up to 350 feet above it. They have in most cases very smoothly oval, gracefully moulded outlines, with steep slopes on each side, more gentle ascent at each end, and a beautifully rounded top. In area they range, in proportion to their hights, from a length of a few hundred feet to about a mile, with usually half or two-thirds as great width. Their longer axes here trend southeasterly and vary in direction from south-southeast to east-southeast, taking the courses of the latest currents of the ice-sheet upon this area. Though drumlins are distributed in profusion on this part of our coast, they are also found in equal abundance upon large inland tracts of Massachusetts and southern New Hampshire, to hights of 1,500 feet above the sea in the vicinity of Monadnock mountain, on the watershed between the Merrimack and Connecticut rivers. Their numbers mapped by me in New Hampshire, under the direction of Professor Hitchcock for the Geological Survey of that state,

are nearly 700; and Mr. George H. Barton, mapping them in Massachusetts, under the direction of Prof. N. S. Shaler, for the United States Geological Survey, finds about 1,500 drumlins, counting, as in New Hampshire, the separate rounded summits of compound drumlin aggregations, where two or three of these hills, and sometimes more, are merged together at their bases.

Nearly all of the many sections of drumlins shown in the vicinity of Boston by artificial excavations, and more extensively by the high cliffs where these hills are being worn away and freshly undermined by the sea, reveal only till. very compact and containing frequent or plentiful boulders up to five feet or rarely ten feet in diameter, which, like the smaller embedded stones and pebbles, usually have glaciated forms and often preserve distinct glacial striæ. This deposit is the direct product of the ice-sheet. Any traces of assortment or stratification by water are exceedingly rare. Instead, the till derived from glacial transportation and deposition is seen in numerous sections to extend quite from the base of these hills, or from the sea level, upward through their central part to their crests. The compactness of the till, its abundant glaciated stones, the peculiar lamination of its clayey matrix, due to the gradual surface accretion, and other characteristic features, clearly demonstrate it to be an accumulation formed beneath the weight of the overriding ice-sheet, whose current moulded the growing drumlins in their smooth oval forms, having their longer axes parallel with the latest movement of the ice over them. Only a small amount of finally englacial drift, apparently averaging no more than from one to three feet in the neighborhood of Boston, was dropped on these hills from the ice-sheet when its waning border retreated past them.

After studying the drumlins of New Hampshire and eastern Massachusetts more than ten years, I first learned of the observation of an instance with a nucleal stratified deposit by Mr. Dodge's description of the sea-cliff section of Great Head, which rises by a steep newly undermined slope, and near the top vertically, to a hight of 100 feet above the ocean. This section consists of ordinary till, weathered yellowish above but dark bluish below, from its top to within 20 or 15 feet

above mean tide, where its base, more fully exposed several years ago during the construction of a railroad than at the present time, was observed by Mr. Dodge to be a somewhat arched bed of "loose, clean, rather fine gravel." This was seen to be overlain by till, which exhibited traces of an imperfect stratification close to their line of separation but above is entirely unstratified.

In the autumn of 1888 it was my good fortune to find two other sections of drumlins which more amply display this interesting structure, namely, the Third and Fourth Cliffs of Scituate, Mass., about twenty-five miles southeast of Boston.

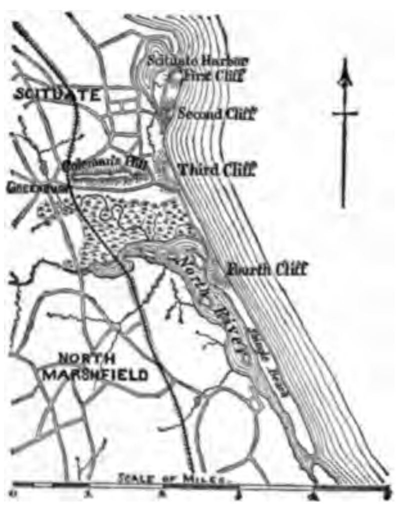


FIG. 4. Map of portions of Scituate and Marshfield, Mass.

These drumlins, respectively about 70 and 60 feet in hight, consist of till upon their whole surface and to a depth that varies from 15 to 25 feet and more, but below include beds of

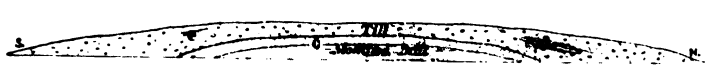


FIG. 5. Section of Third Cliff; length, about 3,000 feet; hight, 70 feet above the sea. (The base of the section is at the top of the shore of boulders, 10 feet above the sea.)

modified drift that attain in Third Cliff a thickness of at least 30 to 40 feet, reaching to the boulder-strewn shore, and in Fourth Cliff a thickness of 10 to 20 feet, being seen there to be underlain by till and to be also in part interbedded with it.

Detailed descriptions of these sections, with figures of them and a map showing the four sea-cliffs and a remarkable esker called Coleman's hill, extending a mile westward from the

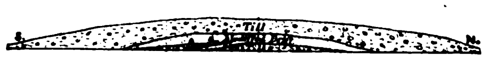


FIG. 6. Section of Fourth Cliff; length, about 2,000 feet; hight, 60 feet above the sea.

drumlin of the Third Cliff, are given in the second of my papers in the Proceedings of the Boston Society of Natural History before cited. By the kindness of the secretary of this society, I am permitted also to present here these figures and map, for comparison with the Madison drumlins which are

FIG. 7. Part of the section of Fourth Cliff, on enlarged scale; length, about 400 feet; hight, 55 to 60 feet above the sea.

shown in Plate III. The extraordinary structure of the till-covered hill of Third Cliff, and its topographic position in the same east and west line with the esker of Coleman's hill, convince me that the two were formed rapidly and in close succession, the esker after the drumlin, during the retreat of the ice-sheet, here withdrawing from east to west, at the end of the Glacial period.

SIMILAR DRUMLINS, WITH MORE NUCLEAL STRATIFIED SAND, IN MADISON, WISCONSIN.

Three hills of this class or type, each having a large central mass of stratified sand and fine gravel, with a superficial veneer, mostly 5 to 10 feet thick, of boulder-clay or till, stand in an east to west series forming the most conspicuous elevations of the city of Madison, Wisconsin. The state capitol crowns the eastern one of these peculiar drumlins; the oldest building of the state university is on the summit of the second; and the crest of the third and most western, where the president of the university formerly lived, is now, since 1878, the site of the Washburn Observatory and of the resi-

dence of the astronomer, Prof. George C. Comstock. They are accordingly known as the Capitol, University, and Observatory hills. Madison lies about a dozen miles east from the eastern border of the large driftless area of Wisconsin, which there is bounded by the outermost or Kettle moraine of the later drift. Toward this moraine the ice-sheet in the vicinity of Madison moved southwestward, as is shown by the courses of glacial striæ on the somewhat infrequent exposures of the bed-rocks.

Altitudes of these hills and others in Madison and of the contiguous lakes, Mendota or Fourth lake, close on the north, and Monona or Third lake and lake Wingra, close on the south, I have received from the contoured map of the city in the office of Mr. McClellan Dodge, the county and city engineer, and in part from Prof. Nelson O. Whitney. Further notes, as given in the following table, of the altitudes of the avenues of drainage from this district southward to the Rock river and from the watershed west of Madison and lake Mendota westward by the Black Earth river to the Wisconsin, and the hights of the most prominent points within a score of miles northward and eastward, from which directions the glacial currents and drift of this area came, are derived from the reports and atlas of the Geological Survey of Wisconsin by Profs. Chamberlin and Irving and their assistants.

Altitudes in Madison and its vicinity.

	Feet above the sea.
Lake Michigan, mean surface above mean tide sea level....	581
Rock river at Beloit, on the south line of Wisconsin........	731
Rock river at the mouth of Catfish creek (Yahara river), about	775
Lake Koshkonong, about....................................	781
Lake Kegonsa, the First lake of the series tributary by Catfish creek to the Rock river............................	841
Lake Waubesa, the Second lake............................	842
Lake Monona, the Third lake, low water, the datum of the Madison city levels....................................	843
Lake Mendota, the Fourth lake............................	851
Lake Wingra, shallow, west of lake Monona and tributary to it..	847
Madison, the eastern railway depots.......................	849
Madison, the western depot of the C. M. & St. P. railway...	856
Top of Capitol hill..	918

Top of a higher drumlin about a quarter of a mile northwest, at the residence of Senator William F. Vilas (called Langdon hill on a following page)	928
Depression between the last and Capitol hill	890
Drumlin crest on East Gorham street, nearly a half mile north-northeast from the capitol	880
Two drumlins, each rising about 25 feet above the adjoining land, a half mile and one mile east-northeast from the eastern depots, crests about	875
Low land crossed by Lake and Murray streets, at the eastern base of the University hill, about	860
Top of University hill	955
Depression between University and Observatory hills	920
Top of Observatory hill	952
Dairy house of the Wisconsin Agricultural Experiment Station farm, on the western slope of Observatory hill	902
Residence of Prof. F. H. King, about a sixth of a mile southwest of the last	875
Surface along the course of a south to north series of experimental borings by Prof. King, at the west end of Observatory hill, passing about a dozen rods west of the dairy house	867–872
Swamp two to three miles west of lake Mendota, on the watershed between this lake basin and the Black Earth river, tributary to the Wisconsin river, about	935
Cross Plains, on the Black Earth river six miles farther west, depot	859
Mouth of Black Earth river, 27 miles west-northwest of Madison	728
Highest points of the country within twenty miles to the north, northeast, and east from Madison, consisting partly of the crests of drumlins, but including quarried rock outcrops up to nearly 1,050 feet, situated seven to twelve miles northeast from Madison	950–1125

Capitol hill, if bounded at each end by a contour line 15 or 20 feet above lake Monona, has a length of about 4,000 feet, trending from northeast to southwest. On the shore of this lake, along a distance of a quarter of a mile, the margin of the hill has been eroded to a steep bank 20 to 30 feet high. Measuring thence across the Capitol Park to the depression separating this drumlin from that of Senator Vilas' residence, we find the width of the Capitol hill to be about 2,400 feet, having a ratio to its length of 6:10. A large space on its top, including most of the Capitol Park and some adjoining land to the extent of fully a quarter of a mile from north to south

and a sixth of a mile in width, is nearly flat, with a hight of 70 to 75 feet above lake Monona.

In the boiler room of the capitol building a well 1,015 feet deep obtains water which rises from its lower portion to 60 or 70 feet below the surface. The section shown by this well is boulder-clay from the surface to a depth of eight feet; stratified sand, enclosing occasional boulders, reaches thence 60 feet; and gravel occupies the next twelve feet, to a total depth of 80 feet, where the boring appears to have passed into shaly beds of the Potsdam sandstone formation. It is possible, however, so far as the record indicates, that the next 46 feet also are referable to the drift, being boulder-clay or till. Numerous other sections on this hill, as for cellars and cisterns, pass through the till in five to fifteen feet, coming to sand beneath. At 80 feet, or less probably 126 feet, the capitol well goes into the Potsdam sandstone, which extends to a depth of 805 feet from the surface and is succeeded thence to the bottom by Archæan crystalline rocks.*

The top of the bed rock under the center of the Capitol hill, if reached immediately beneath the gravel, lies at a greater hight than the beds of lakes Monona and Mendota, the maximum depths of which, according to Prof. E. A. Birge, are for the former probably about 50 feet, and for the latter 75 to 80 feet. The greater part of the area of lake Mendota, six miles long and two to four miles wide, seems, by Prof. Birge's two transverse series of soundings, to be a rather flat tract, depressed 50 to 75 feet below the lake level. Probably under these lakes a considerable thickness of drift overlies the bed rock, perhaps as much as its average on the surrounding land.

Northwest of the Capitol hill, an equally long but narrow drumlin reaches from the northeast end of East Gilman street west-southwesterly along that street and Langdon street nearly to Lake street. At its northeast end this drumlin rises with the usual steep slopes, but toward the southwest it is prolonged in a very slowly declining ridge. Its top is 85 feet above lake Monona. Its surface and the eroded bluff, 20 to 40 feet high, where its northern side has been worn away by lake Mendota, consist of till with plentiful boulders. Prof.

*Geology of Wisconsin, vol. ii, 1877, pp. 50, 605.

G. E. Culver informs me that a well dug many years ago on the upper part of the steep northeast end of this drumlin reached the bed-rock nearly at the level of this adjoining lake; and that another well 50 feet deep, on the southwestern slope near the crest, is said to be wholly in till.

About a sixth of a mile of lowland till, only 10 feet above lake Mendota, separates the western end of the Langdon hill, as the last may be called, from the eastern foot of the University hill. Beginning close east of Park street and of the Science and Library Halls, this hill, more nearly round than any other in its series, extends about 1,600 feet from east to west with a width of about 1,300 feet, not including the margin of probably 100 feet which has been eroded by lake Mendota on the north. The original ratio of the width to the length of University hill was therefore approximately 7:8. The natural section of its northern slope cut by the lake erosion shows sand to a hight of 15 or 20 feet, enveloped by a superficial deposit of about 8 feet of till, whose boulders are strown in abundance on the shore. The top of this hill is 104 feet above lake Mendota.

An excellent section to a depth of about 10 feet and 500 feet long, crossing the eastern slope of University hill about midway between its foot and top, was supplied in 1892 by the trench for laying a large steam pipe from the boiler house to the new Law building. At each end this trench found the till to reach from the surface to a depth of 5 to 8 feet, being underlain by sand. Thence the till gradually diminishes in thickness toward the central part of the section, where for a distance of some 200 feet or more the sand rises quite to the surface. This portion of the central sand mass, destitute of its usual covering of till, forms a slightly protuberant swell, one to five feet in hight above the general slope, from close to the base upward for two-thirds of the hight of the hill. Nowhere else on any of these drumlins does their nucleal modified drift have any natural exposure at the surface, being, with this exception, everywhere veneered by the boulder-clay or till.

From the capitol to the original main building of the University, that is, from center to center of the Capitol and University hills, is a distance of one mile in a due west course.

Adjoining the west end of University hill, beyond an intervening depression of 30 feet below their summits, rises the Observatory hill, 101 feet above lake Mendota, about 1,300 feet long and two-thirds as wide, trending from east to west, but with its western extremity slightly deflected southwestward. The observatory is 57 rods west of the University main building, and 39 rods from lake Mendota. A contour line 70 feet above the lake, at the level of the sag between the two hill tops, encircles an upper area of the Observatory hill 450 feet wide and 1,100 feet long, having nearly the ratio of 2:5.

An excavation for a cess-pool at the top of this hill close to Prof. Comstock's house, reaching a depth of 21 feet, found the boulder-clay 7 feet thick, and all its lower portion was in sand and gravel, the coarsest layers containing pebbles up to six inches in diameter. Here and there a few boulders, up to two feet in diameter, were encountered in the stratified drift. Three to six rods southwest of the observatory, an excavation in the southern slope to a depth of 20 or 30 feet was worked many years ago to supply sand and gravel for masons' use and road repairing. Much gravel and many boulders of small and large size are embedded in the superficial till of this hill, as seen by me on its surface and in excavations to the depth of ten feet for the foundations of the Agricultural College green-house, near the dairy house on its western slope. On the very top, only about four rods west of the observatory, a boulder of Archæan gneiss, ten feet long, lies half or more embedded in the till. Prof. R. D. Irving stated the depth of the drift under the top of this hill to the bed rock to be 122 feet.* Under its western part, at the dairy house, according to Prof. F. H. King, a well 48 feet above lake Mendota went six feet in till, and all its remaining depth, to a total of 84 feet, in sand and gravel, not reaching the bed rock.

SUBGLACIAL DEPOSITION OF THE NUCLEAL BEDS.

In Madison, as in Winthrop and Scituate, Mass., I regard the nucleal sand and gravel of these drumlins as a subglacial deposit, brought to its present place by streams flowing from the melting surface of the ice-sheet during its final recession. The sand and gravel were gathered, as I think, from englacial

*Geology of Wisconsin, vol. II, p. 625.

drift which had become superglacial, being exposed on the ice surface by ablation. Loaded with these materials, the superglacial streams encountered crevasses, down which they plunged. Wholly beneath the ice-sheet, or within its lower part, at the level whence the waters flowed away under or within the ice, bearing their finer silt and clay onward, the beds forming the center of these hills were accumulated. In the case of the Madison drumlins, the avenue of outflow of the subglacial or more probably englacial stream appears to have been the col, now a swamp about 85 feet above lake Mendota, which divides that lake basin from the Black Earth creek, flowing into the Wisconsin river (figure 1, plate III).

The locations of the three large drumlins in Madison which are known to enclose stratified sand and gravel as their central and chief masses, forming an east to west series, seem to me to point very surely to their close relationship in origin. When this Green Bay lobe of the ice-sheet receded from its Kettle moraine, convergent slopes of its surface from the north and south and from a considerable area eastward probably turned the waters of its melting and of rains toward the east to west line of these hills and toward the Black Earth col. The principal stream of this depression upon the ice, falling through crevasses during several or many summers, appears to have massed first the chief part of the Observatory hill, and eastward successively the nucleal beds of the University and Capitol hills (figures 2 and 3, plate III).

Not only these great accumulations of sand and gravel were so deposited, but also similar beds were laid down on the lowlands and overspread by till west of the Observatory hill and east of the University hill. A series of eleven borings by Prof. F. H. King on the Agricultural Experiment Station farm, along a line one-fourth of a mile long from south to north passing across the western base of Observatory hill, found the till to range from 8 to 20 feet in thickness, attaining its maximum at the end of the longer axis of the hill, where a boring was stopped at 20 feet by a boulder. All the other borings of the series passed through the till and went several feet in gravel, which undoubtedly is continuous with the chief mass of the hill. On the flat and slightly lower surface within a sixth of a mile farther west the superficial de-

posit of till contains notably fewer boulders and less gravel than on the hill and close to its base, and its thickness is decreased to 5 feet or in some places only 3 feet. At Prof. King's house, 24 feet above lake Mendota, the till is 8 feet deep, underlain by 12 feet of sand and fine gravel, to the bed rock at the depth of 20 feet. Likewise on the lowland east of the University hill, a well at Prof. Birge's house, about 10 feet above lake Mendota, went 8 feet in till, and several feet into sand below.

One reason for an exceptionally large proportion of sand in the drift of this area is found in the underlying Potsdam sandstone, which reaches five miles northeastward and twelve miles northward from Madison. Prof. Irving suggested that the basins filled by the lakes north and south of this city were probably made chiefly by glacial erosion of this soft sandstone.

When the border of the ice-sheet had retreated so far as to uncover the land here, much further deposition of sand and gravel as hillocky and ridged low kames and eskers, occasionally enclosing boulders but not overlain by till, took place on the area extending from a half mile to one and a half miles south of the University hill. The most noteworthy of these deposits is an esker a half mile or more in length from southeast to northwest and 30 to 60 feet high, which forms part of the northeastern shore of lake Wingra and reaches southward beyond Fitchburg street. Excavations in the southern part of this gravel and sand ridge show an irregular stratification with a prevailing northwestward dip, varying from 15° to 45°. The glacial river by which the esker was formed, walled by ice on each side occupying the present areas of lakes Wingra and Monona, flowed to the northwest, transverse to the previous direction of the glacial movement over this tract, but toward the Black Earth col and the avenue of the somewhat earlier glacial drainage to which I think the accumulation of the sand and gravel cores of the Madison drumlins was due.

ACCUMULATION OF THE OVERLYING TILL.

Above the sand and gravel in these drumlins there is so scanty a veneer of till that we may readily assign nearly all of it to the probably somewhat uniformly thick sheet of finally

englacial and superglacial drift contained in the ice and exposed on the surface when its boundary was withdrawn across this area. On the lowlands adjoining the hills this sheet appears to have been from three to eight feet thick. Neither there nor on the hills do I see need of supposing, with Prof. R. D. Salisbury,* that some part of the fine silt of this till had been blown upon the ice-sheet from the driftless area, unless it may be so small an addition as the "cryoconite" observed by Nordenskiöld and Nansen on the western half of the Greenland ice-sheet.†

My observations, like those of Profs. Chamberlin and King, find the till upon the Madison drumlins more plentifully charged with boulders and smaller stones than the correlative deposit on the lowlands. The transportation of these rock fragments from the adjoining portions of the ice-sheet to the drumlin hills I think attributable to convergent glacial currents flowing downward from contiguous higher tracts of the ice to the depressions of its surface beneath which the sand and gravel had been amassed.‡ In reference to the theory of the origin of drumlins which I present in the paper here cited, I may reply to the principal objection urged against it by Prof. W. M. Davis,§ Mr. George H. Barton,‖ and Prof. T. C. Chamberlin,** namely, the local derivation of much of the drift forming the drumlins, that I have partly considered this objection in the original paper, as it seems to me sufficiently for such drift as is derived from distances of one mile or more. The upward moving basal currents of the ice probably carried the drift up from the land to hights equal to that of the largest drumlins within one or two miles of advance, as is shown by the Pinnacle hills esker, Rochester, N. Y. Moreover, wherever drumlin accumulation took place on a land surface, with no ice beneath, as may have been the more common way, much

---

*Am. Geologist, vol. xii, p. 172, Sept., 1893.

†Am. Geologist, vol. viii, p. 147, Sept., 1891.

‡"Conditions of Accumulation of Drumlins," Am. Geologist, vol. x, pp. 139–162, Dec., 1892.

§Proceedings, Boston Soc. Nat. Hist., vol. xxvi, pp. 17-23, Nov. 16, 1892.

‖Ibid., pp. 23-25.

**Journal of Geology, vol. i, pp. 259-261, April-May, 1893; also see pp. 521–524, July-Aug., 1893.

drift from the land, carried forward subglacially while the drumlin was being amassed, would be commingled with its previously englacial drift. Especially where such a drumlin appears to have been formed upon a rock knob, thereby concealing it, as instanced by Chamberlin from observations of Mr. Buell in Wisconsin, the englacial drift and many fragments from the knob on which it was accumulated must be intermixed in the growing drift hill. The idea of Prof. Davis that the englacial drift in becoming superglacial by ablation must be mostly or wholly washed, assorted, and stratified on the ice surface by the water and streams produced in its melting, seems not to be supported by the prevailing character of the drift covering the border of the Malaspina ice-sheet; and it was not so supposed by me for the waning border of the Pleistocene ice-sheet in the process of its concentration of the drift to form these hills. After reading Prof. R. S. Tarr's recent paper on this subject,* I still believe the usual drumlins consisting wholly of till to have been formed from englacial drift which had become superglacial and was afterward enclosed as a stratum of drift in the ice-sheet. By this view I think that all the peculiarities of distribution and grouping of the drumlins may be best explained.

Upon a large region extending eastward from Madison drumlins are very abundant, so that Mr. I. M. Buell, assisting Prof. Chamberlin in the glacial field work of the United States Geological Survey, has mapped nearly 2,500 of them in southeastern Wisconsin, finding in some tracts an average of about seventy-five for each township six miles square.† The country is a moderately rolling or hilly but nowhere very elevated expanse of the Cambrian and Silurian bed rocks, upon which the drift is spread as a somewhat uniform sheet. Above the general drift sheet its drumlin hills comprise usually only a small part of its entire amount. They occupy, even where grouped most closely, perhaps a quarter or third of all the area, rising 50 to 150 feet above the intervening low grounds. It will be a most interesting question to determine whether the Madison type of drumlins has any large representation in this region. Conversations with Profs. Chamberlin and Sal-

* Am. Geologist, vol. xiii, pp. 393-407, June, 1894.

† Am. Geologist, vol. xii, pp. 172, 176, Sept., 1893.

isbury, Mr. Frank Leverett, and Mr. Buell, who all have specially studied the drift around Madison, lead me to think it more frequent there than in New Hampshire, Massachusetts, and New York, where also drumlins are magnificently developed, among which, however, the Madison type certainly is very rare.

NOTES ON THE GEOLOGY OF THE ROCKY MOUNTAINS BETWEEN THE SASKATCHEWAN AND THE ATHABASCA.

By A. P. COLEMAN, School of Practical Science, Toronto, Can.

During the summers of 1892 and 1893 some explorations were made in the Rockies between the headwaters of the Saskatchewan and the Athabasca. The region lies between two fairly well known passes, the Howse pass, leading from the Saskatchewan to the Columbia, and the Athabasca pass, following up Whirlpool river from its junction with the Athabasca and following down Wood river, a tributary of the Columbia. The tract of mountains lying between the two passes, though including some of the grandest mountain scenery in North America, has been almost wholly neglected by scientific observers, and the maps hitherto published represent it very incorrectly.

In 1892 the expedition consisted of Mr. Stewart, of Toronto, Dr. Laird, of Winnipeg, Mr. Pruyn, Mr. L. Q. Coleman, of Morley, Alberta, and the writer; with two Stony Indians as guides. In 1893 the party was limited to Mr. Stewart, Mr. L. Q. Coleman, and the writer. Guides were dispensed with, having been found useless beyond their own hunting grounds. A white man, Frank Sibbald, was employed as packer, and proved very efficient.

The object of the expeditions was mainly topographical, to explore an interesting unexplored region and especially to determine the hight of Mt. Brown, reputed the highest mountain in Canada. The topographical results and a map showing several new lakes and rivers, as well as the general mountain features, will be published elsewhere. It may be mentioned, however, that Mt. Brown was found to be only 9,000 feet in hight, instead of nearly 16,000, as generally stated. There

were many higher peaks in the region explored, but probably none rising above 13,500 feet.

Observations were made on the geological features of the region, and a small collection of fossils was obtained. These were submitted to Mr. B. E. Walker, of Toronto, for determination, and my heartiest thanks are due to him for the careful work bestowed upon them. A few fossils which Mr. Walker was in doubt about were referred to Sir Wm. Dawson and some others to Mr. J. F. Whiteaves, palæontologist to the Canadian Geological Survey. I wish to express my thanks to these gentlemen for their kindness in examining and reporting upon the specimens sent.

The region examined lies between latitude 52° and 53°, and between longitude 116° 15′ and 118° 30′. The mountain ranges have the usual northwest-southeast trend. Minor valleys lie generally between the ranges, but the more important ones are apt to be transverse. The most important river valley between the Saskatchewan and the headwaters of the Athabasca is that of the Brazeau, a tributary of the former river. This fine valley, thirty miles northwest of the Saskatchewan, forms an excellent natural section from the prairies southwest nearly to the Pacific watershed. The Saskatchewan emerges from the main range at lat. 52° 15′, long. 116° 18′. Between this point and the Brazeau the foothills consist of grey Laramie shales and sandstones with some conglomerates, largely made up of chert pebbles derived from the Palæozoic rocks. No fossils were obtained from these rocks, but seams of coal were observed at the crossing of a small tributary of the Saskatchewan, the Atiko-sipi, the largest about three feet in thickness. Shaly impure coal was observed near a still smaller stream a little southeast of the Brazeau gap.

A few miles to the northeast of the Rockies proper there is a discontinuous range of isolated mountains with the usual trend. They rise to 7,000 or 8,000 feet, and are of tilted and folded rocks, probably Palæozoic. The Cretaceous foothills have in general the same northwest and southeast trend and dip of 45° or less to the southwest or the south-southwest that are observed in the mountains, with a steep escarpment toward the northeast. Usually, however, the dip is much gen-

tler than 45°, and from the softness of the materials the forms of the hills are softened and covered with forest or sod.

Entering the "gap" of the Brazeau and following up the river to its sources, we pass a succession of "tilted block" mountain ranges, seven in all. Our work was confined to the left bank of the river.

The first mountain was wholly of limestone, somewhat fossiliferous. The specimens obtained were poorly preserved, but are described by Mr. Walker as "a ramose *Favosites*, the impression of a brachiopod (*Productus?*), and three sections of gastropods not in condition for further determination, probably Devonian."

The next mountain climbed, a few miles farther up the river, was of highly fossiliferous limestone. A stratum near the bottom yielded the following species, as determined by Mr. Walker:

Atrypa reticularis Linn.; several specimens, all of the small variety found in the Chemung group of the Devonian.

Spirifera disjuncta Sowerby.

Spirifera cyrtinæformis H. and W.

Spirifera orestes H. and W.

Orthis iowensis Hall. This, in common with some other Devonian species of Orthidæ, is doubtless only a variety of O. striatula Schlotheim.*

Rhynchonella castanea Meek; young individual.

Productus subaculeatus Murch.

Diphyphyllum (Eridophyllum) strictum E. and H.

The corallites are smaller than in eastern specimens, being only two lines at the widest, with the usual periodic constrictions. In size and arrangement of interior this species agrees with D. simcoense Billings, but the calicular gemmation is distinctly shown. The second, third, fourth and fifth species belong, in the east, to the Chemung group of the Upper Devonian.

From the next mountain to the southwest only one fossil was obtained, a coral, described as follows:

Cyathophyllum, sp.? Externally it presents the appearance of Cyathophyllum (Blothrophyllum) decorticatum Billings, and doubtless it belongs to that group. The central area, however, has no flat transverse diaphragms. The epitheca is removed, and the outside area presents at irregular intervals the extensions of the arched vesicular plates as in Blothrophyllum. In cross-section there is the typical appearance

*Cont. Can. Pal., vol. I, pt. III, p. 218.

of Cyathophyllum, surrounded by an unoccupied area, which again is surrounded by the edges of the arched, vesicular plates. It is much larger than Cyathophyllum athabascense WHITEAVES, but appears to be closely related to it.

The next mountain up the Brazeau forms a sharp ridge of limestone with a little slate, dipping 40 degrees to the southwest. The fossils collected are all Upper Devonian, as determined by Mr. Walker:

Spirifera disjuncta SOWERBY; long-winged variety.
Strophomena rhomboidalis Wilckins.
Streptelasma rectum Hall.
Fenestella sp.

The next ridge has a gentler slope and consists of yellowish brown clay slate, partially covered by a thick bed of rough cherty limestone. No fossils were found.

Then follows a small group of mountains just southwest of Brazeau lake, having a dip of 28° to the northeast, the reverse of the usual tilt in the region. The rocks observed are sometimes oölitic limestones, but often they appear to be conglomerate beds, containing thin, shaly pebbles and cemented by more ferruginous material which weathers yellow. Weathered surfaces often present a marked concretionary structure and form shell-like hemispheres, from a few inches to a foot or more in diameter. The chief fossils observed are trilobites, Mr. Walker describing the specimens brought back as "several small slabs covered with glabellæ of a *Proetus* closely allied to *P. nevadæ* Hall, of the Devonian."

Near the foot of this mountain a cut bank of shale beside the north fork of the Brazeau is quite fossiliferous and is apparently a small outlier of the Cretaceous. Specimens of plant remains from this place, which were submitted to Sir Wm. Dawson, proved too fragmentary for determination. Mixed with them he found some scales of animal origin, probably remains of fishes and arthropods. Of some brachiopods from the same place, sent to Ottawa, Mr. Whiteaves remarks:

The three specimens from Cut Bank (Camp 18) contain, as you say, a small Lingula, but I am not sure by any means what Lingula it is. Taken in connection with your statement that the specimens occur with fossil plants, it seems not at all unlikely that they belong to the Kootanie series of Sir William Dawson.

At the headwaters of the south fork of the Brazeau, a moun-

tain more than 10,000 feet high consists of limestone, oölitic in part, with a dip of 30° to the southwest. Beneath the limestone, in the valley, thick beds of flesh-colored quartzitic sandstones and conglomerates crop out. No fossils were obtained either from the limestones or sandstones.

Two passes were traversed between the Brazeau and the Kooetnay plains on the Saskatchewan, an eastern one following up Job's creek and down Rock creek, and a western one along Cataract river. Along the former pass there were mountains of limestone with some slate, tilted 45°-50° to the southwest. Reddish quartzite crops out in the lower part of the Rock creek valley. Some of the tilted mountains to the southwest of the pass have folded foothills in front. Corals were collected at the summit of the pass, but by accident were lost.

Southwest of the Cataract pass several mountains are but slightly tilted and take on cathedral shapes. The rock observed is chiefly pink or purplish quartzite, often with transverse bedding.

Near the head of Cataract river is a small sheet of water which we named Pinto lake. The rocks surrounding it are chiefly limestone; and from Plateau mountain, just west of it, numerous fossils were obtained, which have been determined by Mr. Walker as follows:

Atrypa reticularis: several specimens, mostly above the average size.

Pleurotomaria?

Diphyphyllum arundinaceum BILLINGS. In the size of the corallites and the manner of gemmation these specimens agree with D. arundinaceum. They may be only a larger variety of D. stramineum BILLINGS; and, if so, one of the many varieties included by Rominger under Diphyphyllum (Eridophyllum) simcoense BILLINGS.

Pachyphyllum woodmani WHITE: one very perfect specimen.

Slab with weathered branches of Trematopora, etc.

P. woodmani indicates that the rock is Upper Devonian.

Near the ford of the Saskatchewan on the Kootenay plains, and not far from the left bank of the river, a mountain forming a sharp anticlinal fold was ascended and named Triangle peak. Mr. Walker determines the fossils found there as:

Spirifera disjuncta SOWERBY: several specimens, with the usual variations in shape.

Athyris (cf. A. cora HALL). The few specimens are all so exfoliated

that the exterior characters cannot be determined. They are larger than those illustrated by Hall.

Part of a valve of a Productus, showing numerous spines.

Cast of a Bellerophon.

Zaphrentis prolifica BILLINGS; a single specimen.

Syringopora perelegans BILLINGS.

These are all from the Upper Devonian. The first is found in the state of New York only in the Chemung group; but elsewhere it ranges from the Middle to the Upper Devonian, inclusive. The next to the last species is found in the east in the Upper Helderberg and Hamilton groups. The last appears to be confined to the Upper Helderberg in the east, but Walcott states that in Nevada it is found throughout the whole Devonian series.*

Turning northwest from the headwaters of the Brazeau, we find along Jonas pass steep quartzite mountains dipping in the usual way; and the same continue along the right bank of the Sun-wapta, the eastern branch of the Athabasca, and more or less along the main river as far as to Athabasca falls, a distance of about fifty miles. Above the mouth of Jonas creek, on the west bank of the Sun-wapta, a mountain rising above 10,000 feet is of limestone.

Southwest of the Sun-wapta and of the Athabasca below the junction of the former river, the mountains no longer have the regularity observed in the northeastern portion of the Rockies. The subordinate ranges lose the uniform northwest and southeast trend so characteristic farther east. The river valleys can no longer be divided into two sharply defined directions, one parallel to the strike of the tilted blocks and the other transverse to it. Many of the mountains, such as Fortress and Quincy, near Fortress lake, are of the castellated or cathedral type with nearly horizontal strata and very steep walls, the result of erosion. The rocks observed east and north of Fortress lake are purplish quartzites and quartzitic conglomerates. South of the lake, along Misty creek, bluish grey limestones with yellowish streaks occur, and the strata dip toward the south, while the mountains present a bold front northward.

Misty mountain, 10,000 feet, in lat. 52° 20′, long. 118°, consists chiefly of limestones showing bluish grey and yellowish bands or concretions. The moraine of a glacier descending

*U. S. Geol. Survey, Monograph VIII, 1884, Paleontology of the Eureka District, p. 5.

from its flanks consists of a variety of rocks, including limestones, sometimes containing chert, sometimes oölitic, and at times having curious concretionary structures; greenish slate; and black shales with white veins of quartz or calcite, the latter often satin spar of the fibrous variety. A few fossils obtained from moraine blocks were examined by Mr. Whiteaves, who writes:

> One of the specimens contains numerous valves of a species of Obolella, with fragmentary portions of a trilobite, probably Olenellus. The other contains an imperfect trilobite, possibly Ptychoparia. These give me rather the impression of belonging to the Lower Cambrian or Olenellus zone.

Along the Athabasca below the falls and near the mouth of the Miette, slates crop out, dipping at one point 45° to the southwest, and at another nearly vertically, with an east and west strike. These slates and some obscure schistose rocks appear to underlie somewhat metamorphosed conglomerates with interbedded chloritic layers. In the conglomerate angular fragments of slate are sometimes included. Along the lower portion of the Miette, which enters the Athabasca from the west, nearly vertical beds of somewhat metamorphosed conglomerate form the prevailing rocks.

Ascending Whirlpool river from the Athabasca, the rocks for a few miles up are quartzites and conglomerates, both showing scales of mica. The mountains have the usual tilt for the greater part, though a few present nearly horizontal strata. Fifteen or twenty miles up the river the mountains show fine examples of folds and the rock changes to limestone with some slate. Near the summit of the pass dark grey slates appear, along with shiny, wrinkled sericite schist. On Mt. Brown the rock observed was chiefly slate with a shimmer of sericite, some specimens containing cubes of pyrite. At the Committee's Punch-bowl, the summit of Athabasca pass, the prevailing rocks, chiefly boulders, are slates and quartzitic sandstones. The schistose rocks of this pass are evidently of metamorphic origin, modified sediments, by no means perfectly crystalline. They resemble somewhat the sericite schists of the Columbia valley, near Surprise rapids and lake Kimbasket. They are the only schistose rocks which I have observed in the Canadian Rocky mountains. Eruptives

do not, so far as I have observed, occur at all, and the schistose rocks are not found east of long. 118°.

Comparing our observations with the admirable work of Mr. McConnell in Bow pass, we may conclude that the chief fossiliferous beds observed, Upper Devonian according to Mr. Walker's determination of the fossils, correspond to the Banff limestone of Bow pass, there considered Lower Carboniferous or Upper Devonian. The species of fossils referred to by McConnell, "a *Rhynchonella* like *Rocky-Montana*, another like *R. metallica*, *Atrypa reticularis*, a *Spirifera* like *S. whitneyi*, also species of *Athyris*, *Productus*, *Lichas*, *Eridophyllum*, and *Diphyphyllum*,"* are in general like those obtained along the Brazeau and neighboring streams, but they do not appear to agree very closely. Whether the oölitic limestones found at several points in our region correspond to McConnell's Castle Mountain group, which is Cambrian,† cannot be settled until fossils are found. The only instance where fossils do occur, not in the oölite but near by, is near Brazeau lake, about 8,000 feet above the sea level, where a *Proetus* closely allied to *P. nevadæ* is found, probably Devonian.

McConnell describes the shales associated with the Banff limestone as passing into sandstones and quartzites. Whether the thousands of feet of similar rocks observed by us, forming independent mountain ranges, as along the Sun-wapta, or underlying the limestones in other parts, are of the same age, it is impossible to say.

We found no equivalent of McConnell's Halysites beds.‡ The structural features described by McConnell in Bow pass correspond in general to those along the Brazeau, but of course details are entirely different.

It will be of much interest to compare the region described in this paper with that along Howse pass traversed by McConnell in 1892. His work will doubtless afford material for connecting and completing our fragmentary investigations.

A brief reference should be made to the superficial geology of the region traversed. Evidence of glacial action is wide-

*Geol. Sur. Canada, Annual Report, new series, vol. II, for 1886, p. 19 D.

†Ibid., pp. 24-29 D.

‡Ibid., p. 21.

spread in the shape of moraines, lakes dammed with loose materials, polished and striated rock surfaces. In fact the Ice age still exists in a shrunken condition in the hundreds, perhaps even thousands, of glaciers to be found on the higher summits. A score may often be observed from a single point, e. g., any summit along the Sun-wapta. A glacier traversed by us on Misty mountain is nearly three miles in length, with a magnificent ice fall. Many others are much longer and larger than this, especially east and west of Fortress lake; but all appear to be shrinking, as proved, in some instances, by a series of terminal moraines below the present ice foot, the lowest tree-covered, the higher ones still bare. The lowest level of permanent ice observed was at the foot of a large glacier which comes down to the level of the valley, 4,400 feet, on Whirlpool river near the summit of the Athabasca pass.

Since the retreat of the ice from the lower levels there has not been time, e. g. along the Brazeau, for the formation of very high terraces, though most of the river valleys show traces of terracing. North of the Saskatchewan nothing at all like the fine terraces of Bow river was observed. The many lakes, ranging in size from Fortress lake, eight miles long, to mere ponds, indicate also a comparatively recent retreat of the ice. The wearing away of a small amount of rock would drain Brazeau lake, which is separated from a violent rapid by only a few feet of quartzite. The fine waterfalls of the Sun-wapta and Athabasca have cut their way back through cañons, sharp-walled but only a few hundred yards long, indicating only a short period of action under present conditions.

To sum up the geological features of the region examined, we may describe the southeastern portion, well displayed along the Brazeau river, as consisting of a series of seven or more minor ranges, each striking northwest and southeast, and tilted 25°-45° toward the coast line of the Pacific. These blocks, consisting of thousands of feet of quartzite and conglomerate, often overlain by thousands of feet of Devonian limestones, appear to have been thrown into their present attitudes by a series of reversed faults, as described by McConnell in Bow pass. The rare folds observed in this portion

of the mountains perhaps represent the dying out of such faults. Though no Cretaceous rocks have been proved to overlie the Devonian strata, it is probable that the faulting which produced the mountains took place since Cretaceous times, for the foothills of Laramie sandstones give evidence of parallel faulting and tilting.

On approaching the watershed of the Rockies west and northwest of the region just referred to, the regularity of structure largely disappears. The direction and amount of dip vary, folds are not uncommon, and the rocks become more or less micaceous and metamorphosed; slates and sericite schists underlie the quartzites and conglomerates; and fossiliferous beds were not observed. The apparent absence of eruptive or plutonic rocks is a feature worthy of note in a region where faulting has taken place on so huge a scale.

The evidence of the action of Dr. George M. Dawson's Cordilleran ice mass is distinct; the time which has elapsed since the Ice age has been comparatively short; and the innumerable glaciers of the region represent the shrinking remnants of the ice-sheet.

NOTES ON THE GEOLOGY OF THE COAST RANGES OF CALIFORNIA.

By H. W. Turner and T. W. Stanton, of the U. S. Geological Survey.

The following fragmentary notes were made some years ago during the investigation of the quicksilver deposits of the Pacific slope by the U. S. Geological Survey. With the exception of those given in the notes on Yolo county, all the determinations of the fossils have been made by Mr. T. W. Stanton, of Washington, D. C.

The Chico-Tejon series.

It was stated by Prof. Whitney and Dr. Gabb that the upper Cretaceous (Chico) beds of California and the Téjon beds (now known to be Eocene) are conformable; and Dr. Gabb gives a list of species of mollusks said to be common to the two formations. In 1882 Prof. Angelo Heilprin* published a review of Gabb's work in a paper, "On the age of the Téjon rocks of California and the occurrence of ammonitic remains

*Proc. Phila. Acad. Sci., 1882, pp. 196-214.

in Tertiary deposits," in which he showed that there is considerable doubt as to some species given in Gabb's list being found in both the Chico and the Téjon formations. Mr. G. F. Becker* confirmed the work of Whitney and Gabb, as did also later Dr. C A. White. However, neither Mr. Becker's party nor Dr. White found any fossils common to the two formations. Lately Mr. J. S. Diller and Mr. Stanton have found evidence of the unconformity of the Téjon on the Chico in Oregon and northern California. A doubt therefore arises as to whether the conformity of the Chico and the Téjon in central California is real or only apparent.

The most important paper supporting the position of Dr. Gabb is that by Dr. C. A. White.† The locality visited by Dr. White, where the conformity seems best shown is New Idria, in Fresno county, concerning which he writes as follows:

Although this New Idria series is understood to be practically an unbroken one, there is near its middle a recognizable change in the aspect of the strata, so that * * * * the upper half differs from the lower half. It is upon this indistinctly definable horizon that Dr. Becker divided the series into two groups, for the purpose of arranging the results of his studies of them. So far as can be determined, this indistinct line accords with the necessarily artificial division that has been made of the series into the Chico and the Téjon groups, since this series is recognized as containing only these two groups, and the line of demarcation between them, as before shown, cannot be expected to be distinct. Fossils were collected by Dr. Becker's party from various horizons in the series, but in a large portion of it none were found, and those from the lower or Chico portion are very few. These latter, however, are of characteristic types, being species of *Ammonites*, *Baculites*, *Trigonia*, *Inoceramus*, and *Lima*. It is proper to mention that in this New Idria series of strata no commingling of the Cretaceous species above referred to with Tertiary types of fossils was actually observed; but very few fossils of any kind were obtained at this locality, especially in the lower portion of the series. Still the intimate relation of the Chico and Téjon groups for this particular locality is well shown by the unbroken character of the series of strata which here constitutes both groups.

The Chico strata at New Idria, as measured on the ridge west of San Carlos creek, have an average dip‡ of about 45°-

*Bull. U. S. Geol. Survey, No. 19.

†Bull. U. S. Geol. Survey, No. 15.

‡The Chico beds in this section near the contact with the metamorphic rocks to the south dip at high angles varying from 60°-90°, and the dip gradually becomes less going north, away from the metamorphic aréa and upward in the geological horizon. Near the contact with the Tejon sandstones the dip is 30°-45°.

50° to the north and a vertical thickness of about 5,000 feet. The thickness of the Téjon strata cannot be less than 1,000 feet and is probably much more. The lower portion of the Téjon beds consists of white sandstones, sometimes much reddened by iron oxide, and overlying the sandstone is a considerable body of white shale. This shale is beautifully exposed on the north side of a canyon which extends in an approximately east and west direction, draining westerly into San Carlos creek. This east and west canyon was named De los Reyes canyon.

The Chico strata contain some conglomerate at the base of the series, the pebbles of which are of various rocks, quartz-porphyry pebbles being abundant. We did not detect this rock in place, however, in the area of older rocks to the south.* There are also some dark shales with limestone nodules in San Carlos creek above the New Idria P. O.; but tawny sandstones comprise the bulk of the Chico strata at New Idria, and the line of contact of these tawny sandstones with the overlying white sandstones was used as the line of demarcation between the Chico and Téjon formations on the geological map† of the New Idria district. The only determinable fossils in the Chico beds, however, came from near the base of the series, as stated in the quotation from Dr. White. The line of division is therefore an arbitrary one, but it is certain that the white sandstone is of Téjon age, since it contains characteristic fossils. As stated by Mr. Becker and Dr. White, the Chico and Téjon strata at New Idria are apparently conformable, and this is likewise the case at Mount Diablo.‡

The following lists of fossils, collected chiefly by H. W. Turner, will aid the future student of the Chico-Téjon series there. All of them are from Téjon strata, overlying with apparent conformity the Chico series:

De los Reyes canyon.—This drains into the canyon of San Carlos creek from the east at a point one mile north, by com-

*The abundance of quartz-porphyry or quartz-porphyrite pebbles in the conglomerate of the Chico formation at New Idria and at Mount Diablo, and in the Knoxville beds at Knoxville, is rather remarkable, inasmuch as no quartz-porphyry was found in place in the areas of older rocks at any of these points.

†Atlas accompanying monograph XIII, U. S. Geol. Survey.

‡Bull. Geol. Soc. Am., vol. II: H. W. Turner's paper on Mt. Diablo.

pass, from the New Idria Post Office. At the time that the fossils were collected (1884) a Mexican named De los Reyes lived at the mouth of the canyon, and his name was given to the canyon for use in notes.

Localities 160-165 Coast Range collection. These are all near together on the north side of De los Reyes canyon, about 4,800 feet northeast of the mouth.

Ostrea idriaensis GABB.	Amauropsis alveata (CON.).
Neverita globosa GABB.	Cardium, undet. cast.
Rimella canilifera GABB.	Cardium cooperi GABB.
Cylichna costata GABB.	Turritella, fragment.
Morio (Sconsia) tuberculatus GABB.	Meretrix uvasana CON.

Locality 167 C. R. is about one mile up stream from the mouth of the canyon. The sandstone bluff here on the north side has curiously eroded cavities, some of which are inhabited by little owls.

Amauropsis alveata (CON.). Meretrix uvasana CON.

Localities 170 and 171 C. R. are about one and two-thirds miles up stream from the mouth of De los Reyes creek, and about two and a half miles northeast of the New Idria P. O. The fossils were collected by W. A. Raborg.

Neverita globosa GABB.	Cylichna costata GABB.
Amauropsis alveata (CON.).	Mactra sp. undet.
Cardium cooperi GABB.	Rimella canilifera GABB.

Just north of De los Reyes canyon is another canyon extending likewise in an easterly to westerly direction. This joins San Carlos creek at a point about 1,600 feet north of the mouth of De los Reyes creek.

Localities 166, 168 and 169, C. R. coll., are all close together in this canyon and are about 4,500 feet up stream (east) from the mouth, and about two and a third miles N. 25° E. from the New Idria post office. The strata here dip 20°-30° toward about N. 50° W.

Ostrea idriaensis GABB.	Modiola ornata GABB.
Pecten interradiata GABB.	Lucina? cretacea GABB.

About one and a half miles northeast of the New Idria P. O., and about 3,500 feet west of San Carlos creek, is a bed of dark flinty shale in the Téjon formation. This weathers to a buff color. It contains abundant fish scales and spines, and one nearly perfect fish about three or four inches long was obtained. This is now in the collection of the State University at Berkeley, Cal. Dark shales, not so much hardened as at the above locality, occur along San Carlos creek farther to the north, also containing abundant fish scales. None of these fish beds have as yet been investigated.

About three miles northwesterly from the New Idria P. O. is a coal bed which has been prospected for coal by means of a tunnel. The following fossils, collected within fifty feet of the coal seam, show the coal to be of the same age as at Mount Diablo, namely, Téjon.

Solen (Hypogella) diegoensis GABB.
Small lamellibranch, undet.
Neverita, sp. undet.

The following fossil localities are grouped according to counties:

FRESNO COUNTY.

Outside of the New Idria fossil localities, which are likewise in Fresno county, the following are given:

Locality 186 C. R. Twelve miles north of New Idria, on San Carlos creek. Age, Chico.

Baculites chicoensis TRASK.
Pecten.
Corbula.
Nucula.

Locality 187, C. R. Big Panoche creek, east of the mouth of San Carlos creek, and just where the creek leaves the hills and enters the plains of the San Joaquin valley. Age, probably later than Téjon.

Pecten, sp. undet.
Fish scales.
Dentalina and other foraminifera.

Locality 189, C. R. By a creek called Dry Arroyo on Whitney's six miles to the inch map. This creek runs parallel to San Carlos creek and about two to three miles east of it. The locality is six miles east of north from New Idria. Miocene or later.

Nucula, probably N. castrensis HINDS.

SAN BENITO COUNTY.

Locality 178, C. R. On the ridge between San Bartola creek and the San Benito river, and ten miles southwest of New Idria. Age, probably Miocene.

Arca.
Mactra.

The same strata are exposed on San Bartola creek.

Locality 195, C. R. San Benito river, near the 49th mile post from Hollister, and about twelve miles south of west from New Idria. Chico group.

Coralliochama orcutti WHITE? Weathered fragments, probably of this species.
Pectunculus veatchi GABB?

Locality 196, C. R. West bank of the San Benito river, near the 37th mile post from Hollister, and about four miles southeast of San Benito.

Crushed echinoid, probably Miocene or later.

Locality 200, C. R. In heavy bedded sandstone on the San Benito river, about one-fourth mile down stream from the Park mills. Age, Miocene or later.

Scutella-like echinoid.

SONOMA COUNTY.

Locality 339 C. R. On the seacoast, about four miles north of Timber

Cove, is a bed of conglomerate forming part of the Wallala beds* (Cretaceous). In this conglomerate was found a *Turritella* that may belong to T. seriatim-granulata GABB (not ROEMER).

LAKE COUNTY.

Locality 358, C. R. About seven miles northeast of Mt. St. Helena and about two miles southwest of Round Valley, near a branch of Bucksnort creek, is a small area of little altered beds, which contain poorly preserved fossils. Mr. Stanton considers the beds of Cretaceous age, but is uncertain as to the exact horizon.

Mactra (Cymbophora) ashburneri GABB ?
Caryatis nitida GABB ?
Solemya ? sp. undet.
Helicoceras breweri GABB ?
Ammonites, a fragment of a young specimen, possibly A. breweri GABB.

Locality 35, C. R. South side of Cache creek, about one mile east of Lower Lake village.

Crassatella uvasana CONRAD (Téjon group).
Leda, sp. undet.
Natica, sp. undet.

The following are from the same series of beds as 35 C. R., and are from Herndon creek, near Lower Lake:

Cucullæa mathewsonii GABB.
Crassatella, sp. undet.
Turritella ?

YOLO COUNTY.

Along Oat creek, just west of the alluvium of the Sacramento valley, are a series of low hills, composed of little consolidated material, which are interesting since they contain vertebrate remains and other fossils. The locality is near Black's station on the railroad to Colusa. The place was visited by the writer some years since and some of the fossils collected. An elk antler three and one-third feet in length, pine cones, decomposed wood of more than one sort, a tooth, and some shells, were found in place.

The shells were referred to Dr. W. H. Dall, of Washington, D. C., who reported upon them as follows:

The fossils from Oat creek, Yolo county, California, comprise:

Planorbis trivolvis SAY.
Planorbis parvus SAY.
Anodonta sp.?: fragments, probably A. fluviatilis L.

They are not characteristic of age; might be anything from Pliocene to Recent, and are all found living in the same region.

In the higher hills west of these early Pleistocene strata, silicified wood and fossil bones are said to occur. A large tooth and some large bones, probably of a mastodon, were found in the bed of Oat creek; but whether they came from

*Bull. 22, U. S. Geol. Survey.

the low Pleistocene hills or from the probably Pliocene hills containing silicified wood, was not determined.

Fossil bones are also said to occur along Bird creek, north of Oat creek and to the west of Dunnigan's station.

GROWTH OF KNOWLEDGE CONCERNING THE TEXAS CRETACEOUS.

By JULES MARCOU, Cambridge, Mass.

In a paper by Mr. R. T. Hill entitled "Geology of parts of Texas, Indian Territory and Arkansas adjacent to Red River" (*Bull. Geol. Soc. America*, vol. 5, pp. 297-338, Rochester, May, 1894), there is an attempt to show "the progressive evolution of knowledge concerning the Cretaceous formation of Texas," and at the same time the author givés what he calls his "final classification of their succession and nomenclature" (p. 316) in a table called "Progressive Development of Knowledge of the Texas Cretaceous" (p. 317).

The views expressed by Mr. Hill need many corrections, additions and suppressions to show truly with exactness the evolution of knowledge of Texas Cretaceous. I have elsewhere given repeatedly my appreciation of the work done by Mr. Hill in Texas and Arkansas; that he means well, there is no doubt; that he has the talent to make good stratigraphical observations is undeniable; but somehow he does not always give credit where credit is due, and is inclined too often to pass unnoticed over the observations and criticisms which interfere more or less with his preconceived views. Mr. Hill is generally obscure and unsteady in his descriptions, conclusions and classifications, seeming to have no conception of different *facies* for the same group of rocks, which leads him to create subdivisions neither wanted nor truly real. With these reserves and remarks I will point out the corrections and additions necessary to show the evolution of knowledge of Texas Cretaceous.

Ferdinand Roemer is the first geologist who worked at Texas geology. He came into Texas at the end of 1845, during the month of December, and left it in April, 1847. In 1849 he published his volume of travel (Texas, 8vo, Bonn), con-

taining a chapter "Gesteine der Kreideformation," pp. 373-387, and a "Geognostische Karte von Texas"; and in 1852 he completed his publication by the issue of a quarto volume, *Die Kreidebildungen von Texas und ihre organischen Einschlüsse*, Bonn. On page 25 of the last work he gives his conclusions and general section of the Cretaceous strata of Texas as follows: (1) The Cretaceous formation is composed exclusively of limestone. (2) In the plains at the foot of the Texas plateaus the Cretaceous strata are composed of white limestone, more or less marly, of small thickness; while on the plateaus the rocks are very thick, hard limestone, alternating with beds of silex and marls. (3) The Cretaceous of Texas belongs in totality to the deposits posterior to the Gault and corresponds to the White chalk (étage Sénonien, d'Orbigny) and the upper part of the Chloritic chalk (étage Turonien, d'Orbigny).

Roemer does not seem to have seen anywhere the superposition of his two groups of Cretaceous rocks, called by him Cretaceous of the plains (the Cretaceous at foot of highlands, of Hill) and Cretaceous of the plateaus (Cretaceous of highlands, of Hill), although he inclined toward the idea that the chalk of the plains is older than the chalk of the plateaus, a rather grave error. On his geological map Roemer colors, as Cretaceous, parts of Texas which do not contain Cretaceous rocks, but are covered by the Carboniferous, the Dyas, the Trias, and the Jura; the three last great formations having entirely escaped his researches.

In 1852, Dr. G. G. Shumard accompanied, as a surgeon and naturalist, Capt. R. B. Marcy, in an "Exploration of the Red river of Louisiana." He repeated the conclusions of Roemer in regard the Cretaceous formation of Texas, referring it to the *Etage Sénonien* d'Orbigny.

In 1853, I explored the 35th parallel of latitude, with Lieut. A. W. Whipple's expedition, for a Pacific railroad survey. In my two reports, printed in 1855, and dated July and September 1854, in House Documents 129, Washington, I recognized the Neocomian at Comet creek, Fort Washita, and on the Elm fork of the Trinity river, showing for the first time in North America the existence of the Lower Cretaceous as in Europe. I developed my observations and published sev-

eral Cretaceous fossils, with their exact position in the stratigraphical scale, and also a general geological map, besides a detailed geological map of a part of New Mexico and the "panhandle" of northwestern Texas, in my quarto volume, *Geology of North America* (Zurich, Switzerland, 1858). These are my conclusions: "I have seen and studied the strata of the Upper Greensand and the Marly Chalk in the bed of Little river, one of the affluents of the Canadian, and also on the Elm fork of Trinity river; further, I have recognized the Neocomian resting in discordant stratification on the New Red sandstone on the left bank of the False Washita, near Comet creek; and, finally, I have found in the beds of white sandstone and gray marl of the environs of Albuquerque and Galisteo, New Mexico, fossils that have led me to consider those strata as the equivalents of the White chalk of Europe." In my paper: "Rèsumè explicatif d'une Carte gèologique des Etats-Unis et des Provinces anglaise de l'Amerique du Nord" (*Bull. Soc. Geol. France*, 2d series, vol. XII, p. 883, Paris, May, 1855), I gave a long description of the Cretaceous of Texas, with lists of fossils and correlations with the great European formations of (1) the Neocomian, (2) the Greensand and Marly chalk, and (3) the White chalk. That classification and discovery was a great step toward a rational and exact definition of the Cretaceous rocks of Texas, and it gave positive knowledge instead of the very vague and erroneous generalities of Roemer.

But my observations, instead of being accepted and used for further improvement of our knowledge of the Texas Cretaceous, were on the contrary opposed systematically; and the first geological survey of Texas, instituted in August, 1858, under the direction of Dr. Benjamin F. Shumard, proposed, in 1860, a classification of the Cretaceous strata of Texas, so extraordinarily erroneous that it became a matter of duty to science to criticise and rearrange the section given by Shumard as the standard of the classification of Texas Cretaceous. I did it in 1861, under the title, "Notes on the Cretaceous and Carboniferous rocks of Texas" (Proc., Boston Soc. Nat. Hist., vol. VIII, pp. 86-97).

In Mr. Hill's table, my classification of 1853-58 is passed over entirely, and I am placed after Dr. Shumard's work of

1860, just as though what I had done several years before Dr. Shumard came to Texas did not exist. My answer to Shumard was only in order to maintain my classification and discoveries of 1853, and to try to put a little order in one of the most confused and erroneous sections of strata ever published.

I shall not refer to the geological report of the United States and Mexican Boundary commission, in which Mr. James Hall declared that the entire Cretaceous strata of Texas were the prolongation and representatives of his Nebraska section Nos. 1, 2 and 3, that is, the Dakota, Fort Benton and Niobrara formations.

In 1886 Mr. Hill began to classify the strata of a part of Texas, between Fredericksburg, Austin, and the southwestern side of Arkansas. I was glad to see that he did not fall into the great mistakes made by Roemer, the two Shumards, and James Hall. His report on "The Neozoic geology of southwestern Arkansas," published in 1888, showed me that he mistook the division called by him Trinity, as belonging to the Cretaceous, when it is plainly a Jurassic group of strata, containing a Jurassic fauna, without any mixture whatever of Cretaceous forms. I revised his whole list of fossils and proved that his Trinity division of Texas and Arkansas belongs to the Jura ("Jura, Neocomian, and Chalk of Arkansas," in the AMERICAN GEOLOGIST, Dec., 1889, pp. 357-367). Mr. Hill has never paid any attention to my paper; and, without taking the trouble to refute my determination of his fossils, he has continued to place his Trinity division in the Lower Cretaceous. Not knowing personally any part of Texas except the northwest corner of the state, I was inclined at first to accept the classification and synchronism of Mr. Hill, believing that he possessed sufficient ability to give with exactness all the details of the formation. Only I was badly impressed by his frequent changes for the subdivisions of the Lower Cretaceous, and thought that he had placed too high the horizon of what I have called "the *Gryphæa pitcheri* zone or limestone of Comet creek," which for me is, with the "Caprina limestone," the lowest bed of the Neocomian or Lower Cretaceous of Texas.

Now I have no doubt that he has made serious mistakes in regard to half of his Lower Cretaceous or Comanche series,

as he sometimes calls it. The "Caprina limestone" cannot be separated from the "*Gryphæa pitcheri* limestone" at Comet creek and is the basal bed of the Lower Cretaceous. All the strata below do not belong to the Cretaceous, but to the Jura or New Red sandstone. There is a great break of the strata, with a complete change of geographical distribution in northern Texas between the group of strata containing the *Caprotina texana* Roem. and the *Gryphæa roemeri* Marc. (formerly called by Roemer and Marcou the *Gryphæa pitcheri*) and what has been called by Mr. Hill the Fredericksburg and Trinity divisions, and by me at the Tucumcari area the Jurassic formation of North America.

The subdivision introduced at different times in the Fredericksburg seems to be local, simply different *facies* of the upper part of the Trinity. Correlations between the Jurassic strata of the Tucumcari and the Trinity and Fredericksburg divisions have not yet been established. It is a good field to work in. The fauna of the upper part of the Jurassic strata of Pyramid Mount at the Tucumcari, thanks to the collection made there in 1889 by Prof. A. Hyatt, is now well known; and with such characteristic fossils as *Gryphæa dilatata*, var. *tucumcarii* and *Ammonites belknapii*, it must be easy to define with exactness and distinguish in Texas the Jura and the Neocomian. All the strata that exist below the zone of *Gryphæa tucumcarii* and *Ammonites shumardi*, and that zone itself, are older than the Cretaceous system and belong to the Jurassic system. All the strata above, containing *Caprotina texana* and *Gryphæa roemeri* (formerly the *Gryphæa pitcheri* of Roemer and Marcou), belong to the Cretaceous. The Lower Cretaceous in Texas is composed of what Mr. Hill calls the Washita division (including in it his "Caprina limestone") and is what I have called, since 1853, the American Neocomian.

One word more, about a question of priority which seems to have escaped Mr. Hill, although I have privately called his attention to it. Mr. Hill refers the species described and figured by Roemer, in 1852, and by me in 1855-58, under the name of *Gryphæa pitcheri* to a species figured twenty-five years later, in 1880, by Dr. C. A. White under the name *Gryphæa forniculata*, as a new species, confounded before with the *G. pitcheri*. Roemer made the mistake to refer a *Gryphæa*

that he had found abundantly in the vicinity of New Braunfeld, to the *G. pitcheri* of Morton. As he had the opportunity to show his specimens, when passing through Philadelphia in 1847, to Dr. S. Morton, I thought he was right, and, following in his steps, I called the *Gryphæa* found by me in such abundance at Fort Washita and at Comet creek *Gryphæa pitcheri* of Roemer and Morton. When endless discussions, started by Messrs. James Hall, Shumard, Meek, and Gabb, on the identification of Texas *Gryphæa*, all referred by them to the typical *G. pitcheri*, showed plainly that mistakes had been made all around, in order to keep intact my observations at Comet creek, I took care to print in a foot-note of my paper, "Notes on the Cretaceous and Carboniferous rocks of Texas" (Proc., Boston Soc. Nat. History, vol. VIII, January, 1861, p. 95), the following remark: "Thus we shall have three species of *Gryphæa*: 1, the *G. tucumcarii* of the Jurassic rocks of Pyramid Mount (New Mexico); 2, the false *G. pitcheri* of Roemer and Marcou, or the false *G. pitcheri* var. *navia* of Conrad and Hall, of the Cretaceous rocks of the False Washita river (Texas), which may be called *G. roemeri* in honor of its first discoverer, Mr. F. Roemer; and 3, the true *G. pitcheri* Morton...."

It is evident from that quotation that Dr. C. A. White ought to have called the *Gryphæa pitcheri* of Roemer, *Gryphæa roemeri*; and that his name of *G. forniculata* cannot be accepted, according to rules of *priority*. American paleontology has been saddled with such numbers of incorrect determinations of Mesozoic fossils, that if we do not return to the question of priority, as an immutable rule, then nothing is left but fancy and consequently inextricable and systematic confusions. Happily, I have given such excellent figures of the *Gryphæa* found by me at Comet creek, drawn by the great fossil artist, Hubert, that doubt is not possible. After calling it in 1854 and 1858 *Gryphæa pitcheri*, I did not hesitate, as far back as 1861, to say that it was a new species which I called then *Gryphæa roemeri*, a determination fully justified since by every observer. Consequently *Exogyra forniculata* White, not *Gryphæa* as Mr. Hill says by mistake, has to go into synonymy and be dropped.

The accompaning table of the growth of knowledge of the

TABLE OF EVOLUTION OF KNOWLEDGE OF THE TEXAS CRETACEOUS.

F. ROEMER, 1845-52.	J. MARCOU, 1853-58.	B. F. SHUMARD, 1860.	J. MARCOU, 1861.	R. T. HILL, 1886-93.	J. MARCOU, 1894.
Cretaceous of the Plateaus, or Senonian. Cretaceous of the plains, or Turonian.	3. *White chalk* of Galisteo. 2. *Marly chalk* and *Greensand* of the Elm fork of the Trinity and Little river of the Canadian. 1. *Neocomian* of Comet creek and Fort Washita.	*Upper Cretaceous.* Divided into: *Caprina* limestone. Comanche Peak. Austin limestone. Fish bed. *Exogyra arietina* bed. Washita limestone. Blue marl. *Caprotina* limestone.	*Upper Cretaceous, or Senonian.* Austin limestone. Fish bed. Blue marl.	*Upper Cretaceous.* Glauconitic division. Colorado division. Dakota division.	*Upper Cretaceous, or Senonian and Turonian.* All strata above the base of the Dakota.
		Lower Cretaceous. Arenaceous group. Fish bed. Red River group.	*Middle Cretaceous, or Greensand and Turonian.* Red River group. *Caprina* limestone. Comanche Peak. *Exogyra arietina* marl.	*Lower Cretaceous.* Washita division (including Kiamitia clays). Fredericksburg division (including *Caprina* limestone). Trinity division.	*Middle Cretaceous, or Cenomanian and Greensand.* The upper part of the Washita division, including the Vola or Shoal Creek limestone, Arietina beds, and Devonian beds, of Messrs. Hill and Taff.
			Lower Cretaceous, or Aptian and Neocomian. Washita limestone. *Caprotina* limestone.		*Lower Cretaceous, or Aptian and Neocomian.* Fort Worth limestone, Preston beds, and Caprina limestone, of Mr. Hill.
Roemer did not recognize the Middle Cretaceous, or Cenomanian and Albian, nor the Lower Cretaceous, or Aptian and Neocomian.—G. G. Shumard, 1852-53, repeated the name Senonian only.	Marcou recognized, below the Neocomian, the Jura, the Trias and the Dyas of northwestern Texas, the Indian Territory, and New Mexico.	Shumard added later the Ripley group and Dakota division. He referred the Jura, Trias, and Dyas, to the Dakota division.	Marcou's rearrangement of Shumard's section.	Hill does not recognize the Jura in Texas, regarding the whole series as the two lowest divisions of the Texas Cretaceous.	*The Jura*, comprising the Fredericksburg and Trinity or Bosque divisions.

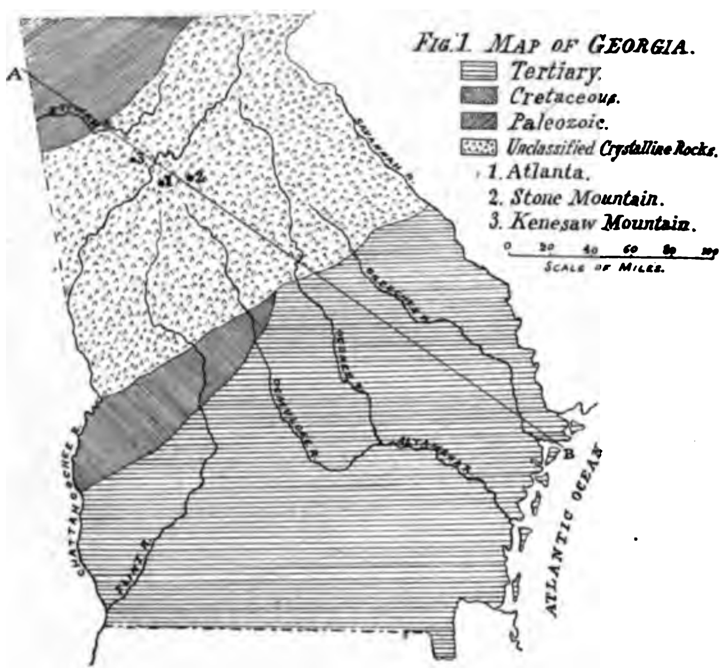


Fig. 2. Section across Georgia along the line A B.
Length, 300 miles; vertical scale, — = 1000 feet.

Fig. 3. Section through Kenesaw Mountain.
——— = 1 mile.

Fig. 4. Section through Stone Mountain.
——— = 1 mile.

MAP OF GEORGIA, WITH SECTIONS.

Texas Cretaceous is clear enough without explanation. It differs mainly from the table published by Mr. Hill in grouping the Caprina limestone of his Fredericksburg division with the Washita division, and in the addition of the Jurassic formation in Texas. I shall publish, by and by, a history of the Texas Jura.

GEOLOGICAL AND TOPOGRAPHICAL FEATURES OF THE REGION ABOUT ATLANTA, GEORGIA.

By Chester Wells Purington, Boston, Mass.

(Plate IV.)

During the past winter opportunity came to me, while in the vicinity of Atlanta, Georgia, to make a few observations on geological features of the region which appear to deserve notice.

As may be seen, by reference to the accompanying map, forming figure 1, plate IV,* central Georgia is a region of crystalline rocks, gneisses and schists for the most part, in contact on the northwest with Paleozoic rocks, and overlain on the southeast by the superimposed beds of the Cretaceous and Tertiary. Although little has yet been done in the way of attempting to correlate this area with others, it is safe to say that these gneisses and schists are of Archean age, in the broader use of the term. Indeed, it is probable that the rocks about Atlanta belong to that limited and lowest division of geologic time to which the more restricted term Archean has recently been applied.

The region is one where much erosion has taken place, and the red clays and soils resulting from the disintegration of the rock lie undisturbed over the gneiss. The red soils are familiar to all who have been in the southern Appalachians. They have been well described by Russell.† The products of decay are in some places fifty feet thick, as can be well seen in deep

*Prepared from the bulletins of the United States Geological Survey, containing the correlation papers of the Archean, Cretaceous, Eocene, and Neocene; and from Prof. J. W. Spencer's report on the Paleozoic group of Georgia.

†Subaërial decay of rocks, and the origin of the red color of certain formations; by Israel Cook Russell. Bulletin 52, U. S. Geol. Survey.

railroad cuts. Prof. Russell says that this weathering extends, in some cases to a depth of one hundred feet, but I saw none which went so deep in this area. So different in appearance are these red beds from the unweathered rock, that I at first took them to be the representatives of a superimposed formation of clays. But on closer examination, the similarity in strike and dip of the clay and of the underlying rock, the occurrence in the clay beds of parallel mica plates and other minerals of the gneiss, and the continuity of quartz veins through the rock and the overlying soils, convinced me that the clay was but the weathered phase of the rock.

It is my purpose to describe a few peculiar topographic forms brought about by the long-continued action of the atmosphere on the formation under consideration. The general dip of the rock is to the southeast, but many local folds occur of considerable extent. In many places, especially on the sides of the low hills, the weathered material has been removed, leaving large, bare outcrops of rock. These outcrops are of two kinds, (1) flat areas, sometimes several acres in extent, and (2) smaller masses which project from the ground with the dip of the rock-bed. These projecting ledges are in some cases 16 feet long, are from 5 to 15 feet broad, and have a thickness of 4 or 5 feet. The average dip of the formation, and consequently of the ledges, is about 40°, although it is sometimes nearly vertical. In the case of a small fold, near Austell, an anticline plunging to the northeast, it was possible, in a ploughed field a half mile in extent, to trace the turning of the strike from southeast, through east, northeast, and north, and this all from one point of view, by means of eight of the projecting ledges arranged in a long curving line.

By the examination of the contoured maps, Atlanta and Marietta sheets of the United States Geological Survey, it will be seen that this region shows the general characteristics of a dissected peneplain, the upland sloping gently toward the southeast, having an average hight above sea level of 1,000 feet on its northwestern edge, and 750 feet on the southeastern. On a very small scale, a section crossing this area and continuing to the sea is shown in figure 2, plate IV. The surface is a rolling hill country in which the streams run in two well defined directions. The Chattahoochee follows the

longitudinal trend of the Appalachian folds, in a southwest direction; while a number of smaller streams, farther east, flow southeast, in accordance with the slope of the peneplain. Hayes and Campbell, in a recent paper,* have traced out the development of the separate Cretaceous and Tertiary peneplains in the southern Appalachians, and have stated that the region of central Georgia is that of least differentiation between the two. According to this, the denudation of the peneplain is the joint product of Cretaceous and Tertiary time, and its dissection must be chiefly referred to late or post-Tertiary agencies.

The maps, however, show that certain parts of the area have not submitted to the general base-levelling process. The most noticeable examples of these extra-resistant masses are Kenesaw and Lost mountains and Stone mountain. The two first are near Marietta, and the latter is about sixteen miles east of Atlanta. The two first mentioned have their longer axes in the direction of the prevailing folds. Kenesaw mountain is a great monocline, its beds of gneiss having a general dip to the southeast of 40°. Lost mountain I have not examined, but its structure is probably not different.

In looking at Stone mountain on the map, one is surprised, at the first glance, to see that its longer axis lies, in a direction at right angles to the strike of the crystalline schists. In a geomorphological sense, all these elevations, Lost, Kenesaw, and Stone mountains, can be classed under the head of monadnocks,† but while Kenesaw is only a massing of extremely resistant beds of the country rock, Stone mountain must be different.

The first view of Stone mountain from the train fixes it as an object worthy of notice. On a near approach, its shape, that of an immense dome, its abrupt and towering hight, its steep sides of solid rock, bare of all soil and vegetation, and streaked by the rain with long white lines, make it a truly remarkable sight. The mass rises directly from the surrounding gneiss, and no talus encumbers the base. It is composed

*Geomorphology of the Southern Appalachians, by C. W. Hayes and Marius R. Campbell. Nat. Geographic Magazine, May 23, 1894.

†A term suggested by Prof. W. M. Davis, in allusion to Monadnock mountain in New Hampshire, and used by Messrs. Hayes and Campbell in the paper referred to above.

of a fine-grained, gray muscovite-granite, homogeneous throughout, and appears to be, as far as can be judged from its present features, an eruptive plutonic body, a true laccolite. The only variation from the even fineness of crystallization is the presence of crystals of tourmaline porphyritically developed, and intergrown with other minerals. These crystals are usually an inch and a half in length. They do not occur at a distance of more than three feet down from the surface of the granite, as I was able to observe in the extensive quarries now being worked upon the mountain.

Since tourmaline is a mineral whose presence in granite usually denotes a contact with other rock, the presence here of crystals of tourmaline near the surface, and nowhere else, is evidence in favor of two things: (1) That Stone mountain has been covered with beds of rock, probably with gneiss like that which surrounds it. The holocrystalline nature of the stone itself bears out this theory. (2) That, although the cover has been removed, little of the granite has been eroded. Indeed, I think it probable that the shape of the mass has been but little changed since the granite cooled. Hence it may be referred to as a stripped laccolitic mass. The mountain reaches two and a half miles in its long diameter, and nearly a mile in its shorter one. The slope of the sides varies from 30° on its southeast side to as high as 70° on the northeast. A granite mass similar to Stone mountain, but much smaller, comes up through the plain twelve miles to the southeast.

The difference in structure between Kenesaw and Stone mountains is roughly shown in the accompanying cross-sections (figures 3 and 4, plate IV).

EDITORIAL COMMENT.

The Columbian Exposition.

Some special State exhibits of the crystalline rocks.

Of the New England States Massachusetts excelled, although Connecticut and Maine also had suites of dressed granite cubes four inches on the edge, the labels of the latter express-

ing where and what buildings have been erected of the various granites exhibited, a feature which was not seen on any other similar exhibit. The most interesting portion of the Massachusetts exhibit was in the gallery of the Mines and Mining building. It was collected by Dr. W. H. Hobbs, C. L. Whittle and Geo. E. Ladd, and displayed many interesting rock structures as well as a large number of minerals. There were many fine samples of margarite, with its divergent cleavage plates, of steatite, with its wavy or step-ladder structure. Margarite, chloritoid and emery were from Chester, the steatite from Blandford.

A polished slab of mica schist, from Great Barrington, loaned by Dr. Hobbs, illustrated the formation of a secondary "banding" transverse to the sedimentary structure. This, however, is hardly a banding, but a schistosity, although it has been mistaken for a sedimentary structure by several geologists. This is the same slab as that used to illustrate Dr. Hobbs' paper on this subject in the Bulletin of the Geological Society of America (vol. iii, p. 460). A mica schist conglomerate, from near the base of the Taconic, from the Hoosac tunnel, contained pebbles of granite and gneiss, and illustrated the manner in which the old fragmentals approximate the petrographic characters of a true crystalline rock. There was also a very nice polished slab of lilac and iridescent scapolite from Bolton. This is associated in a limestone with a variety of minerals, such as diopside, beryl, nuttallite, etc. By Dr. Wolff the conglomerate has been found to pass into gneiss, the pebbles having a micaceous matrix.

A building stone that has acquired some notoriety was exhibited from Somerville. This is a decomposing diabase. Prof. N. S. Shaler protested against its going into "memorial hall," Cambridge, and prevented it. The owners, who lost the contract, brought suit against him for "defamation of property," but as there was no difficulty in proving that the rock is subject to rapid disintegration and has decayed to the depth of twenty feet along the joint planes, they recovered no damages. This stone has, however, lately been used in the foundations of Hastings hall. This collection demonstrated the superior qualifications of practical geologists in getting together such exhibits. It was not wholly "industrial," but

rather educational and scientific. Too many of the state exhibits were prepared by gentlemen who cared only for the economic interests involved, and they got together large quantities of various ores which confronted the visitor on every side *ad nauseam*.

Adjoining the Massachusetts mineral exhibit was that of New York, which had all the variety and volume which might be expected from that state. One of the most striking objects here was a case of green fluorite from McComb, St. Lawrence county. In the collections of the New York State Cabinet was an obelisk made up under the direction of Mr. F. J. H. Merrill, consisting of cut blocks from all the formations of the state, taken from quarries or other sections. It was thirty feet high and four feet square at the base. The cap and top course were of trap and Triassic sandstone, and the base of Archean granites and gneisses. The four sides of the column showed the occurrence of the formations in the respective quarters of the state, each formation being represented by one or more courses, according to its relative thickness. Above the Archean was the "Cambrian," which was divided into Georgian and Acadian, the Georgian being the thickest formation represented in the column, having six courses. The Acadian had two. The Hudson River, including the Utica slate, had five courses. The Potsdam was put at the base of the Lower Silurian and had one course. It did not cover the Calciferous, which also had one course.

The magnetic iron ores from Orange, Essex and St. Lawrence counties, New York, and the Clinton red hematite were well represented; while in the gallery were 102 four-inch polished cubes of the granites and other crystalline building stones.

The Michigan exhibit of crystalline rocks was under the direction of Hon. Peter White, of Marquette, assisted by Julius Roper and by others. Here was a drawing showing the geological succession through the iron districts of the Ishpeming basin, a distance north and south of over seven miles. This brought out the structural relations of the ore deposits and of the associated rocks. The formations concerned were represented by 50 or 60 rock samples. This was made by Julius Roper. There were also 720 specimens of the Archean

rocks, accompanied by a manuscript descriptive list, and a general account of the various ore basins represented in Marquette county. It seemed a great mistake that this was not put into print for the use of visitors, as it was a key to the whole exhibit. From the copper mines there was a large display. The largest mass of native copper on exhibit was from the Central mine, Keweenaw county, and weighed 8,500 lbs. Another had a weight of 6,200 lbs. Two samples of hematite, from the Republic mine, together weighed 10,375 lbs. and were accompanied by the following analysis, showing their average composition:

Metallic iron	68.050
Silica	1.150
Phosphorus	.040
Alumina	.998
Magnesia	.072
Lime	.127
Manganese	.022
Sulphur	.036
Organic and volatile	.290

There was also an admirably constructed section of the Cleveland Cliffs Iron Company's Lake mine, Ishpeming, made in the actual material, showing three levels, and another of the Cliffs Shaft mine. These exhibited the general relations of the ore to the depth of 500 feet, and a horizontal width of 750 feet. Their dimensions were 12 feet high and 18 feet by 18 feet horizontal. Another section illustrated the formation east and west of the Calumet lode, exhibited by the Calumet and Hecla Company. There was also a fine display of verd antique and serpentine marble from the region west of Ishpeming.

Wisconsin exhibited, besides granites and various kinds of building materials, the iron ores of the Penokee range. A large piece of metallic (float) copper was exhibited, found in Jefferson county, having a weight of 1,800 lbs. The most striking object in the Wisconsin exhibit were the four monoliths of lake Superior red sandstone standing at the four corners of the pavilion.

Minnesota had an exhibit of the iron ores of the state, and a series of rock samples from the crystalline rocks, prepared by the state survey. There was also a model of the great

Chandler mine at Ely, which has produced more iron ore, for the time it has been operated, than any other mine in the world.

In the South Dakota exhibit was a natural section of the Homestake gold mine, at Lead City. This is the largest gold mine in the United States, employing 1,800 men. The section consisted of a perpendicular column of seven blocks of rock taken from the mine at intervals of 100 feet, showing the distribution of the ore in the rock. The cheapness of the smelting allows a good profit on the very low grade ore which is taken out. It has an average of $3.75 per ton, varying from $1.00 to $25.00 per ton, the annual output being about $4,-000,000.

The crystalline rocks of Missouri were illustrated by 200 hand specimens, collected by Messrs. Haworth and Lonsdale, of the Geological Survey, and by dressed blocks of granite from the granite companies. The specular ores were also exhibited by specimens. The Archean area of the state was shown by a relief map covering an area of 250 square miles, the horizontal scale being 1:48,000; vertical 1:24,000. This area rises 1,500 feet above the sea. The line of the limestone areas surrounding it is 500-600 feet above the sea. The Archean therefore rises from 900-1200 feet above the adjacent Cambrian areas, and about six square miles of this reaches 1,800 feet above the sea. The rocks represented do not seem to belong to the true Archean, but resemble more in *tout ensemble* the crystalline rocks of the Norian.

Other exhibits of crystalline rocks and associated minerals were seen from New Jersey, North and South Carolina and other states, but the writer happened to visit them when they were closed.

Ward's systematic rock collection in the gallery of the Mining building, was by far superior to anything else of its kind seen in the exposition. This contained several thousand specimens dressed regularly to museum size, from all parts of the world. There was "petrosilex" from Dannemora, Sweden, appearing like the jaspilyte of Minnesota. There was every variety of volcanic rock as well as plutonic, including "quartz-porphyry tufa," from Zeiskywald, Ruchlitz and Wiesa, Saxony, and volcanic bombs two feet in diameter from Monte

Somma, Italy, Auvergne, France, and from New Zealand. These are lenticular generally, but some are much elongated.

N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Twelfth Annual Report of the United States Geological Survey to the Secretary of the Interior, 1890-'91. By J. W. POWELL, Director. Part I. Geology; pp. xiii 675, with 53 plates, and 81 figures in the text. Part II. Irrigation; pp. xviii, 576, with plates 54-146, and figures 81-270 in the text. Washington, 1891.

These valuable large volumes reporting the progress of our national survey during the fiscal year ending June 30, 1891, were distributed to colleges and universities, public libraries, and the working geologists of the country, nearly three years after that date, although bearing the imprint of 1891. In the first volume the director's annual report and the administrative reports of the chiefs of divisions of the survey form 210 pages. These are accompanied by four geological papers, as reviewed in the following pages, forming the remainder of this volume. The second, devoted to the surveys and plans for the improvement of the arid lands of the western half of the United States by irrigation, contains three reports: first, upon the location and survey of reservoir sites, by A. H. THOMPSON, comprising 212 pages, with four plates and 142 figures; second, Hydrography of the arid regions, by F. H. NEWELL, 149 pages, with 49 plates and seven figures; and third, Irrigation in India, by HERBERT M. WILSON, 199 pages, with 40 plates and 41 figures.

In topographic, geologic, paleontologic, chemical and physical work, compilation of statistics of mineral products, the departments of engraving and printing, the library, and disbursements, thirty-two summary reports of the progress of the survey are presented.

Up to date of June 30, 1891, the number of topographic sheets of the United States atlas which had been engraved was 473, comprising about 481,000 square miles. These sheets are on three different scales, according to the character of the country, the proportion of population, and the importance of geologic features to be noted. Thus, 177 sheets have the scale of 1:62,500, or about one mile to an inch, usually with contour intervals of 20 feet, these being mostly in the New England and Atlantic states south to the Potomac river; 237 sheets are on the scale of 1:125,000, or about two miles to an inch, usually with contours for each 50 or 100 feet; and 59 sheets, mostly in the mountainous or desert Cordilleran belt, are on the scale of 1:250,000, or about four miles to an inch, with contours for each 200 or 250 feet. The areas of the sheets for these several scales are bounded respectively by arcs of ¼, ½, and 1 degree in latitude and longitude.

The investigations relative to irrigation include (1) the systematic mapping of the arid regions in order to show the location and altitude of the irrigable lands, their position with regard to the rivers from which the water is to be obtained, and the area, altitude, and character of the catchment basins from which the rivers receive their waters; (2) measurements of the amount of water flowing in the most important streams, with computations of the quantity available for each day of the year, either for immediate irrigation or for storage purposes; and (3) engineering examinations of such localities as the knowledge of the topography and of the water supply seem to indicate as favorable for great irrigation developments. At these places careful surveys are made to test the practicability of diverting the waters of some river and carrying them out by large canals to command extensive areas of arid, though fertile, land, or of holding the flood waters in great reservoirs so that the flow of the streams can be increased in time of drought. These surveys are in each case carried to the degree of testing the feasibility of the schemes from a financial standpoint. This report gives descriptions of 147 reservoir sites, with accompanying hydrographic data, illustrated by maps and diagrams. During the year here reported 21,475 square miles were mapped for this department of the survey, in the states of Montana, Idaho, Kansas, Colorado, Nevada, California, Texas, and New Mexico. The total areas segregated for the reservoir sites are 165,932 acres; and the areas of the reservoirs, at their proposed stages of high water, amount to 108,350 acres. Their contents would be approximately 2,847,815 acre-feet, which, allowing two feet of water for irrigation during the growing season, will supply half as many acres. This is nearly equal to the irrigation crop area shown by the census of 1890 in Montana, Idaho, Wyoming, Utah, Nevada, New Mexico, and Arizona. Most of the sites selected for reservoirs are high in the mountains at elevations of 5,000 to 10,000 feet, where the loss from evaporation will be less than it would be down nearer to the irrigated lands.

Mr. Wilson's paper on irrigation engineering in India gives abundant details relating to economy and permanence which have been there developed through long practice, whereby American engineers may reap the results of much costly experience. He shows the benefits, financial and political, derived from the canals of India, and points out how in many localities the topography, climate and water supply resemble those of our arid West; but with our lower mountain ranges and smaller rivers it is not needful nor possible for us to construct so large canals and reservoirs. W. U.

The Origin and Nature of Soils. By NATHANIEL SOUTHGATE SHALER. Pages 213-345; plates II-XXXI, and figures 1-27. (Accompanying the Twelfth Annual Report, U. S. Geol. Survey.) In this admirably illustrated memoir Prof. Shaler treats, in a style suited to ordinary unprofessional readers, the interesting conditions of soil formation; diverse kinds of soils; causes of the treelessness of prairie areas; the beneficial action of earthworms, ants, the larger burrowing animals, and deeply

penetrating roots; the deterioration or exhaustion of cultivated lands by faulty methods of farming; and the precautions needed to insure permanent productiveness. The pressure of the plow on the part of the soil beneath that which it overturns is shown to be unfavorable for the best tillage, and the invention and substitution of some machine capable of working over and thoroughly loosening the soil as when it is spaded by the gardener are strongly recommended. An outline of this subject had been presented by the author in the final essay of his volume, "Aspects of the Earth," a year or two previous to its elaboration for this report. W. U.

The Lafayette Formation. By W J McGEE. Pages 347-521; plates XXXII-XLI, and figures 28-72. (Accompanying the Twelfth Annual Report, U. S. Geol. Survey.) Upon an area of about 100,000 square miles of the coastal plain in the Atlantic and Gulf states and of the Mississippi valley, extending north to the limits of the glacial drift in northern New Jersey and southern Illinois, the loam, sand, and gravel beds of the Lafayette formation constitute the present surface; and upon areas aggregating twice as much more this formation has been removed by erosion, or lies concealed beneath the Columbia deposits. In thickness the Lafayette beds are described as ranging from a mere veneer over many interstream tracts to 200 feet or more about the mouth of the Mississippi, the variation being in general directly proportional with the volume of neighboring rivers and inversely with the extension inland. In structural relation the Lafayette is separated from the newer Columbia formation by the strongest unconformity of the coastal region, representing the erosion of probably half the volume of the Lafayette formation and profound trenching of subjacent formations along the larger waterways; while the contact with all the underlying formations indicates that during pre-Lafayette time the coastal plain was a land surface and was wrought into a configuration much like that existing to-day. As to their manner of deposition, Mr. McGee holds that the Lafayette beds were laid down in the shallow borders of the Atlantic ocean and Gulf of Mexico, being brought by rivers which are still in existence, when the land stood from 200 to 800 feet lower than now, and when the sea and gulf extended from 50 to 500 miles inland of the pressent coast. In age this formation is regarded as many times older than the earliest known Pleistocene and glacial deposits, but much newer than any other well defined formation of the coastal plain. To account for the deposition of the Lafayette beds, the author supposes their areas to have been depressed beneath the sea. It is noteworthy, however, that no definite beaches, marine fossils, or other proofs of the presence of the sea have been discovered; and the great amount of erosion following the Lafayette deposition required an important continental uplift.

A simpler view of the epeirogenic movements, closing the Tertiary era and inaugurating the Quaternary, seems to the present reviewer to be found in ascribing the Lafayette formation to deposition on land areas by flooded rivers descending from the Appalachian mountain

region and from the Mississippi basin, spreading gravel, sand, and loam over the coastal plain and along the great valley during the early part of a time of continental elevation. The land had lain during the long Tertiary periods at lower altitudes, and its surface was largely enveloped by residual clays and by alluvial sand and gravel. With the elevation of the continent, increased rainfall and snowfall and resulting river floods swept away these superficial materials from the higher lands and spread them on the coastal plain and along the Mississippi valley, where the streams expanded over broad areas with shallow and slackened currents. As the elevation increased, however, the rivers would attain steep slopes and finally erode much of the deposits which they had previously made. During the culmination of the uplift, which the reviewer thinks to have produced the northern ice-sheet, Chesapeake and Delaware bays were excavated and erosion was in progress at a far more rapid rate than with the present low altitude of this region. Prof. E. W. Hilgard, by whom the formation was first studied and named, believes that during Lafayette time the Mississippi valley had a greater descent and stronger currents of its river floods, the increased altitude of the interior of the continent having been apparently 4,000 to 5,000 feet, sufficing probably, in its culmination, to bring the cold climate and ice accumulation of the Glacial period. According to this view the Lafayette period may be considered, as by Hilgard, Spencer, and Smith, to be early Quaternary or Pleistocene, representing the initiation of the conditions which resulted in the Ice age. W. U.

The North American Continent during Cambrian Time. By CHARLES D. WALCOTT. Pages 523-568; plates XLII-XLV, and figures 73-78. (Accompanying the Twelfth Annual Report, U. S. Geol. Survey.) The conclusions reached in this paper are stated by the author as follows: 1. The pre-Cambrian Algonkian continent was formed of the crystalline rocks of the Archean nuclei, and broad areas of superjacent Algonkian rocks that were more or less disturbed and extensively eroded in pre-Cambrian time. Its area was larger than at any succeeding epoch until Mesozoic time. 2. On the east the Paleo-Appalachian system of mountains was outlined by a high and broad range, or system of ranges, that extended from the present site of Alabama to Canada, and subparallel ranges that formed the margin of seas and straits to the east and northeast of the northern Paleo-Appalachians or the Paleo-Green mountains and their northeastern extension toward the pre-Cambrian shore line of Labrador. 3. On the Pacific side the eastern mass of the Paleo-Rocky mountains formed a broad mountain barrier that extended from the present region of Arizona and New Mexico to Montana, and toward the Arctic circle, upon the western side of an interior land area. To the west the primitive Sierra Nevada protected the Nevada sea and extended far to the north. 4. The interior continental area was, at the beginning of Cambrian time, an elevated, broad, relatively level plateau between the Paleo-Appalachian sea on the east and the Paleo-Rocky mountain barrier on the west. 5. At the beginning of Cambrian time three principal

areas of sedimentation existed: (*a*) the Atlantic coast province, including various narrow seas between the several pre-Cambrian ridges; (*b*) a narrow sea extending along the western side of the Paleo-Appalachian range from the present site of Labrador to Alabama; (*c*) a broader sea on the western side of the continent, west of the eastern Paleo-Rocky mountain ranges, that extended from the southern portion of the present site of Nevada northward into British Columbia and probably toward the Arctic circle, and south to the Paleo-Gulf of Mexico and thus connecting with the Paleo-Appalachian sea. 6. Sedimentation probably began in the Paleo-Appalachian and Paleo-Rocky Mountain seas before Cambrian time, and it continued without any known unconformity to the close of Lower Silurian (Ordovician) time in the northern Paleo-Appalachian sea, and with relatively little interruption to the close of Paleozoic time in the Paleo-Appalachian sea south of New York, and in the Paleo-Rocky Mountain sea. 7. The Cambrian sea began to invade the great Interior Continental area in Middle Cambrian time, and extended far to the north toward the close of the period. 8. The depression of the continent in relation to sea level began in pre-Cambrian time and continued with a few interruptions until the close of Paleozoic time. 9. The relative positions of the continental area and the deep seas have not changed since Algonkian time. 10. The sediments of Cambrian time were accumulated to a great extent in approximately shallow seas, except in portions of the Paleo-Rocky Mountain and Paleo-Appalachian seas. 11. The Lower Cambrian fauna lived in the seas of the Atlantic coast province, the Paleo-Appalachian and the Paleo-Rocky Mountain seas. 12. The Middle Cambrian fauna of the Atlantic basin is not known to have penetrated into the Paleo-Appalachian or Paleo-Rocky Mountain seas, except in the case of a few species now found in Alabama and probably eastern New York. The portion of the fauna occupying the same relative stratigraphic position in the group is essentially the same in the Paleo-Appalachian and Paleo-Rocky Mountain sections. 13. The Upper Cambrian fauna was distributed over the broad Interior Continental area and in the Paleo-Appalachian and Paleo-Rocky Mountain seas, but it has not been recognized by the same genera and species in the Atlantic coast province, the fauna of the latter being more closely allied to that of the Upper Cambrian of the eastern side of the Atlantic basin. W. U.

The Eruptive Rocks of Electric Peak and Sepulchre Mountain, Yellowstone National Park. By JOSEPH PAXSON IDDINGS. Pages 569-664; plates XLVI-LIII, and figures 79-81. (Accompanying the Twelfth Annual Report, U. S. Geol. Survey.) The study of the chemical composition of the intrusive rocks of Electric peak and of the volcanic rocks of Sepulchre mountain proves that these two groups of rocks have identical chemical compositions. The varieties that have been analyzed are mineralogical and structural modifications assumed by the magmas on cooling, and the analyses serve as indications of the range of their chemical variability. From the geological structure of the region, the

correspondence between the orders of eruption of the two series of rocks, the resemblance of a large part of the rocks of both series, macroscopically and microscopically, and the chemical identity of all the rocks of both groups, it is conclusively demonstrated that (1) the volcanic rocks of Sepulchre mountain and the intrusive rocks of Electric peak were originally continuous geological bodies; (2) the former were forced through the conduit at Electric peak during a series of more or less interrupted eruptions; and (3) the great amount of heat imported to the surrounding rocks was due to the frequent passage of molten lava through this conduit. The remnant of a volcano, fractured across its conduit, has been faulted and considerably eroded, so that it presents for investigation, on the one hand, the lower portion of its accumulated debris of lavas, with a part of the upper end of the conduit filled with the final intrusions, while, on the other hand, a section of the conduit is exposed within the sedimentary strata upon which the volcano was built. Recognizing the wide extension of similar intricacies in the geological and physical relations of volcanic eruptions, Prof. Iddings thinks it "advisable to base the classification of igneous rocks on that character which may be determined with certainty from the rocks themselves, namely, the crystalline structure, and which, at the same time, is to so high a degree an exponent both of the chemical composition of the magmas and of the physical and geological conditions attending their solidification." W. U.

Popular Lectures and Addresses. By SIR WILLIAM THOMSON (BARON KELVIN); in three volumes. *Vol. II. Geology and General Physics.* Macmillan & Co. 12mo., 600 pp., $2. 1894.

Lord Kelvin's addresses on physical geology in connection with the live question of the length of time the earth may have existed, have such a degree of simple mathematical expression and exactness that they have had much influence in recent calculations by different geologists. In this volume are included also addresses on various subjects of physical science, such as geological climate, the condition of the interior of the earth, the earth's magnetism, the theory of polar ice-caps in relation to changes of the sea level, sound and imperfect harmonies, the heat of the sun, the aurora, etc. N. H. W.

A manual of the study of documents. PERSIFOR FRAZER. J. B. Lippincott & Co., Philadelphia; pp. 218, 1894.

One of the editors of the AMERICAN GEOLOGIST has produced a book on a branch of study which, being entirely new, he has named *bibliotics.* It is the study of writing and writing materials with the view either to establish the character of the writing or to discover fraud. The former, again, he calls *grammapheny*, and the latter *plassopheny.*

This curious volume follows the subject into many lines of research. The physical characters of a specimen of penmanship are minutely examined into, both through ocular inspection and by microscopic methods, and by composite photography. It is wonderful how far these methods have already been employed prior to any attempt to define and

group them. The various methods of making chemical examination of inks used in writing, for the purpose of comparing a genuine with a spurious signature, are given in detail. Then follows a digest of the laws and judicial opinions bearing on the use of expert testimony on handwriting.

Altogether this little manual will be of use in legal and financial circles where the critical examination of all signatures is a necessity. It brings into small compass for the first time just the information often wanted by penmen and experts, which usually is scattered and difficult to use.

N. H. W.

Die Fauna des unteren Devon am Ostabhange des Ural. By TH. TSCHERNYSCHEW. (Mémoires du Comité Géologique. Vol. IV, No. 3, pp. 1-221, pls. I-XIV, 1893.)

This is a work of more than local interest. The author, especially distinguished for his researches upon the Devonian of the Russian Empire, has described in detail a somewhat peculiar faunal assemblage from neighboring limestones on the Asiatic slopes of the Urals, which are treated of as a whole and as of common age.

The American student of paleozoic faunas, after a diligent scrutiny of the fourteen finely executed plates of fossils and of their descriptions, can hardly fail of being impressed with the conspicuous predominance of normal Silurian (Niagara) types in this fauna, here regarded as of lower Devonian (Hercynian) age; and in such a mind the query at once arises: By what construction is a fauna so constituted to be referred to the Devonian? The leading elements of the fauna discussed, briefly stated, are as follows: Among the Trilobites, *Youngia*, a ceraurid like *Pseudosphærexochus*, and of which the only other known species is from the Silurian; *Calymene* (fragment). *Aristozoe* (*A. regina*, Barrande, *A. hercynica*, nov.) Of the gastropods, *Platyceras* (1 species), *Orthonychia elongata* Hall, *O. cultellus*, nov., *Pleurotomaria lindstræmi*, a pauci-spiraled shell with large, ventricose body-whorl; *P. ventricosa*, with angular whorls, high spiral and contracted body-whorl; large Murchisonias with high spirals; large broadly umbilicated Bellerophons (cf. *Trematonotus*, Hall; *Salpingostoma* F. Roemer), sharply carinated species (*Oxydiscus*) and small, non-umbilicated forms of typical structure; well defined *Subulites* (*S. uralicus*, nov.) The leading element of the fauna is the brachiopod, which includes spirifers of the type of *S. radiatus* (*S. turgensis*, nov., *S. robustus*, Barrande) and *S. plicatellus* (*S. indifferens*, var. *transiens*, Barrande); multiplicate lineate species like *S. niagarensis* (*S. tiro*, Barrande), dupliciplicate radiate forms represented by *S. nobilis*, Barr. var. *arbitensis*, nov. Species of the unicispinate fimbriate type (*S. orbitatus* Barr., *S. cogulicus*, nov., *S. pentameriformis*, *S. kuschvensis*). Of the considerable number of species referred to *Merista* and *Meristella*, the critical generic characters are demonstrated in none. Compared with similar shells in American faunas it may safely be said that these bear in respect to form, size and general external expression, a far more pronounced similarity to species of *Whitfieldella* and *Meristina* of the Silur-

ian, than to the Meristas and Meristellas of the Lower Helderberg and Oriskany. Indeed among the identifications we find that of *M.* (*Whitfieldella*) *nitida* Hall, a Niagara species. Numerous small Rhynchonellas occur, of the type of *R. whitii* and *R. indianensis*, of the Niagara: one large form, *Wilsonia pila*, var. *irbitensis*, nov. is like *W. saffordi* Hall. It is the pentameroids that put the Devonian conception to the severest strain. Here we meet a remarkable development of genera which one is wont to regard as eminently Silurian: great plicated Conchidiums of the type of *P. knighti* (*P. pseudoknighti*, nov., *P. rogulicus* Vern., *P. rossicus* Karpinsky, *P. karpinskii*, nov., etc.); *P. taltiensis*, a smooth shelled, true *Pentamerus* of the type of *P. pergibbosus*, Hall and Whitfield and *P. striatus* Eichwald, a form which, in some of its phases, shows the passage of *Pentamerus* to shells with the completely reversed convexity of the valves possessed by the recently described genus *Capellinia*, from the Niagara dolomites of southeastern Wisconsin. This reversal of convexity and predominance of the brachial over the pedicle-valve are well shown on pl. 12, fig. 5. The type of *P. linguifer* Sowerby, *P. ventricosus* Hall (= *Barrandella;* smooth shells with median fold on the brachial valve) is represented by *P. krasnopolskii*, nov.

Among other Silurian forms may also be counted the genus *Pasceolus*, Billings.

Turning to the elements of the fauna which may be regarded as representatives of the American lower Devonian (Lower Helderberg, Oriskany), we shall find them conspicuously few. Isolated species, *Proetus uralicus*, nov., *Orthonychia elongata* Hall, *O. cultellus*, nov., present a Devonian aspect. *Schizodus ? uralicus*, nov., (hinge unknown) has the peculiar form of *Palaeoneilo leda* Hall, of the Hamilton fauna. *Atrypa sublepida* Vern. has the introverted spirals of *Atrypina*; while it bears the external aspect of *Coelospira*. The species identified as *Pentamerus acutolobatus* Sandberger, is a similar shell to the Lower Helderberg species commonly identified as *P. galeatus*, though more sharply plicate. *Strophomena wagranensis* Gruenewaldt, is a *Stropheodonta* with the interplicate crenulated surface of *S. varistriata* of the Lower Helderberg and *S. patersoni* of the Upper Helderberg. *Orthis subcarinata* of the Lower Helderberg is present in the Siberian fauna. More distinctively Devonian types are found among the corals: *Amplexus*, *Cystiphyllum*, *Diplochone* (Frech's genus), *Favosites goldfussi*, *F. polymorpha*, *Alveolites goldfussi*.

The determination of this assemblage as a Devonian fauna seems the logical outcome of recent analytical studies of heterotope faunas, which, beginning with Kayser's, of the oldest fossil-bearing rocks of the Hartz (1878), have been productive of important modifications in the current interpretation of various local faunas. Kayser's detailed investigation of the Zorge and Wieda Schiefer of the Hartz, which A. Roemer had declared to be of Silurian age, demonstrated a predominance of Devonian types; the correlations instituted by him between this fauna and those of the Bohemian étages F, G and H of Barrande, led him to argue the early Devonian age of the latter also. Novák, Katzer, Barrois,

Frech, Tschernyschew, and several others, have, by contributions direct or indirect, endorsed and fortified these determinations, until to-day the post-Silurian age of these and equivalent faunas, including the Lower Helderberg of New York, is no longer debatable. All of these so-called "Hercynian" faunas, so far as they had been previously studied, were originally determined as Upper Silurian. Barrande's conception of the age of his upper étages applied to them all: admitting the correlation of the normal Upper Silurian with his étage E, he regarded the superjacent étages F, G, H, as a continuation of the Silurian not represented in the typical sections of Great Britain, thus a *post*-typical-Silurian. The inclusion of all such faunas within the limits of the Devonian is simply the placing within the latter time-division a series of faunas more or less highly impregnated with derivatives of the normal Silurian. This Silurian element is evident in the Hartz faunas, decidedly more conspicuous in the Bohemian étages and emphatically less pronounced in the Lower Helderberg fauna. In the correlation of newly discovered faunas with these Hercynian faunas, there may be a predominating agreement with the major Devonian or the minor Silurian element. Thus, in Tschernyschew's list of 140 species from this east-Ural Hercynian, subtracting first 53 new, and 9 undetermined species, there are 35 out of the 61 remaining which are regarded as identical with species occurring in the Bohemian étages F and G, and of these 35 there are 13 which also occur in the étage E, or normal Silurian. This 35 is certainly a large commonty between so distant faunas, but the large third of these, which embodies the specific continuations from the Silurian, indicates what is perfectly clear from a consideration of the other two-thirds of the Bohemian element, that this fraction does not represent the Devonian element of the Bohemian faunas, but rather its more distinctly Silurian or neutral elements.

Comparison of the fauna with that described by the same author as Hercynian on the west slope of the Urals, shows a contingent of 28 common species, and this element is, as a whole, more Devonian in aspect than the Bohemian contingent. This fact, together with the Devonian affinities which are otherwise indicated in the fauna itself, shows that the east-Ural fauna, if properly regarded as a single faunal assemblage, is as weak in Devonian types and as strong in Silurian types as a Devonian fauna can well be; that is, it indicates, if Devonian age, a Devonian stage that has heretofore been unrecognized.

While the conventions of geology, the lapses in our knowledge of the geological record and the finitude of human comprehension render necessary the employment of such time divisions as Silurian, Devonian, etc. (and we are disposed to believe that some few years will have elapsed before such terms can be dispensed with, notwithstanding the evident impatience of them manifested by some of our twentieth century geologists), our conception of the limitation of such time divisions and their faunas must be materially influenced by the limitation of their original definition. As a series of rocks the upper limit of the typical Silurian section was clearly defined, and time has shown that this

limit was not only one of a geological series, but the dead-line of a large number of organic types. In the typical Devonian sections, however, the lower boundary was never defined, and English geologists to-day concede that the earliest members of the Devonian series are absent or unexposed in these sections. The Devonian system was founded upon one of the most unfavorable and incomplete developments of that series of rocks and faunas known in any part of the globe; a more precise scope was given to it by the work of its founders, Murchison and Sedgwick, in the Rhineland, but even there no determination of its lower limit was made. This admitted hiatus in the typical succession of Devonian to Silurian, is the parent of the prolific discussions over "post-Silurian" and "Hercynian" faunas. No such discussions could arise in a country, if there be any such, where the interval is filled by a complete succession. In America, in particular the state of New York, where the Lower Helderberg fauna is typically exhibited, there is an absence of physical disturbance in the succession except that indicated by the presence of an extensive local accumulation of gypsum, salt, and water-limestone, toward the close of the Silurian, but the meager fauna of these beds is followed by the exceedingly prolific one of the Lower Helderberg, where but wondrous few of the Silurian species appear. There may be a Silurian expression in many generic elements in the Lower Helderberg, but the entire combination is by no means so early in its general expression, or indicative of so close complications with the Silurian, as that of the Siberian fauna which we have just considered.*

The early geologists of the state of New York, working out the classification of its rocks independently of preconceived notions and alien nomenclatures, applied to the formations now embraced under the terms Lower Helderberg, Oriskany and Upper Helderberg, the name *Helderberg division* (Mather, Vanuxem), or *Helderberg Series* (Emmons, Hall): the most sharply defined and widely extended geological terrane in the state. There was, indeed, some divergence of opinion as to what should constitute the basal member of this division, Hall and Vanuxem including the Onondaga Salt group, Emmons omitting it and beginning the series with the Pentamerus limestone. The original definition of the *Helderberg division* was Mather's and was essentially based upon determinations made by John Gebhard, jr., in the valley of Schoharie creek. This limitation of it begins the series at the bottom with the "Manlius water limestones," and terminates it above with "the Seneca limestone of Mr. Hall." The approximate accuracy of this lower limit as a line of division between the Lower Helderberg and the subjacent formation was afterward established by Prof. Hall. The continuity of the great series of waterlimes constituting the upper part of the Salt group and the lower part of the Lower Helderberg, makes a division upon lithological grounds somewhat uncertain, but the line is fixed, as shown by Hall and emphasized by comparison with the succession in Great Britain and Russia, at the disappearance of the *Eurypterus* fauna.

*For a review of the Lower Helderberg fauna with especial reference to its Silurian and Devonian elements, see Clarke: The Hercynian Question, 42d Rept. N. Y. State Mus. Nat. Hist., pp. 408-437, 1889.

The fauna of the *Helderberg division* is as sharply defined as the terrane which bears it. It is more prolific in species than the Silurian beneath or the faunas above it to the base of the Carboniferous in the state of New York. As an organic complex the interrelations of its component faunas are extremely close and yet they are all characterized by the acmic development of organic groups which give the fauna, taken as a whole, an expression as fundamentally distinct from that which precedes (normal Silurian) as from that which follows (normal Devonian). We would be understood as saying, and the truth of the remark must be apparent upon even a cursory study of these faunas, that any question raised in regard to the age of the Lower Helderberg fauna must concern with equal force the faunas of the Oriskany and Upper Helderberg. In the brief space to which these remarks must be restricted, attention may be directed to such distinctive features as the brilliant outburst of the genus *Dalmanites* or *Odontochile* and its multitude of subgeneric and specific variations (28 species), their high ornamentation and great proportions. Foreshadowed in the Silurian by a few simply dressed species, this great group becomes, to our present knowledge, totally and finally extinguished (except so far as represented by a single species and variety of *Cryphaeus*) with the disappearance of the fauna of the Corniferous limestone. No such remarkable group of Trilobites appeared elsewhere in Paleozoic history, in no other group is such diversity of form, such extravagance of size and ornament (save in the Lichads of the same fauna), and none can be said to more emphatically characterize a period in faunal succession than this. Highly distinctive features are exhibited by the representatives of other trilobitic genera: *Ceratolichas*, *Conolichas*, *Dicranurus*, *Terataspis*, *Ancyropyge*, *Homalonotus*, *Phacops*, and *Cordania*, showing that this crustacean element is in a pre-eminent degree characteristic and indicial, absolved in a truly remarkable manner from entanglement with the trilobitic representation in the faunas preceding and succeeding, more strongly individualized, more prolific, more extravagantly and peculiarly characterized than that element in either.

Barrois, in speaking of the prolific development of *Platyceras* or *Capulus* in the Calcaire d' Erbray, in Brittany, the equivalence of whose fauna with that of the *Helderberg division* he has fully established, has remarked that if the old practice of naming faunas from the presence of certain generic types (Astartian, Virgulian, etc.), were to be continued, the term *Capulian* should, *par excellence*, be applied to that. Of the capulids in the Helderberg fauna there are nearly one hundred described forms, presenting great diversity in structure and ornament. Nowhere else and at no other period does the development of these gastropods in any degree approach this.

Of distinctive and exclusive brachiopod generic types there are many: *Orthostrophia*, *Hipparionyx*, *Leptaenisca*, *Chonostrophia*, *Anoplia*, *Metaplasia*, *Merista*, *Charionella*, *Rhynchospira*, *Plethorhynchus*, *Stenoschisma*, *Uncinulus*, *Eatonia*, *Leptocoelia*, *Amphigenia*, *Rensselaeria*, *Beachia*, *Oriskania*,

Selenella; a significant list even when stated in this brief form without reference to the culmination of other generic, subgeneric and specific types, or to the important evidence afforded by the inception, or absence or decline here of types distinctive both above and below.

The lamellibranchs show series of interesting transition forms: the cephalopods, sparse in the early stages but abundant in the later, possess many highly distinctive genera.

These suggestions may be taken simply as indicative of the constitution of the fauna as a whole, as evidences of an individual expression which closer analysis would only serve to strengthen. There are localities known wherein the fauna of each of the component stages of the *Helderberg division* is complicated with that immediately succeeding: the Lower Helderberg with the Lower Oriskany, the Lower Oriskany with the Upper Oriskany, and the Oriskany with the Upper Helderberg. So, also, there are a few places recorded (e. g., Cass county, Indiana), where the Upper Helderberg fauna is involved with that of the Hamilton group: more will undoubtedly be found: anything else would be unnatural with an uninterrupted succession of strata and faunas. There is likewise, in some respects, a palpable approximation in the later fauna of this division, to that of the Hamilton and typical Devonian. It would be surprising were there not. Who will draw the line between the faunas of the Cambrian and Ordovician? between the Devonian and Carboniferous?

That the fauna of the *Helderberg division* is not Silurian is demonstrated: that it is consequently Devonian is a *non sequitur*. The Devonian is a geological and palæontological entity which has never been defined. As it was originally simply a name for the interval between the Silurian and Carboniferous, so it is to-day. But the fauna of the *Helderberg division*, or the HELDERBERGIAN, is as distinctive from that of the overlying Devonian as it is from the Silurian, and, as already stated, its representation in species is quite as prolific as either of the others. The name proposed by the state geologists of New York has passed into desuetude, giving way to the procrustean adaptation of a European nomenclature by Europeans (Bigsby, de Verneuil, Lyell): but it is a question worthy of consideration whether it may not profitably be revived to express a definite geological and biological quantity: not alone as a distinctive geological term, but as even more distinctive of a series of faunas which in their entirety form a body as integral and homogeneous as any other of the large divisions in the organic history of the Palæozoic. It is not alone in New York or North America that this *Helderbergian fauna* is so clearly developed. Its correlates have been found throughout the world, in Belgium, France and Spain, Germany, Bohemia and Austria, Russia, Siberia, South Africa, Brazil and Bolivia.

European writers have employed the term *Hercynian* for faunas equivalent in whole or part to those of the *Helderberg division*. The name is an unfortunate one, for it has never been clearly defined, has been applied to faunas of widely different geological age or to certain

facies of different faunas, and it may almost be said that no two writers have fully agreed as to its significance or scope. It has, moreover, not the prestige of priority, and, unless its usefulness can be more fully demonstrated, should gracefully yield to the more venerable term.

J. M. CLARKE.

Eighteenth Annual Report, for 1893; Indiana, Department of Geology and Natural Resources. S. S. GORBY, State Geologist. 356 pages; with natural gas and oil map, and 12 plates of fossils. Indianapolis, 1894. Indiana is a state where the peculiarity exists of electing the state geologist by popular vote as the governor or mayor or county surveyor is elected. It is, therefore, a more or less political office, and we see in this a reason for the frequent changes the office has undergone. Since E. T. Cox left the position in 1879, it has been filled by professors Collett, Thompson and Gorby, and the last named will, we presume, be superseded by some one else in the near future. This fact is in striking contrast with what obtains in some other states. In New York, for example, Prof. James Hall has been connected with the survey since 1835, and after an interim of several years has been in charge of a new survey since 1881. In Minnesota Prof. N. H. Winchell has been the state geologist for the past 22 years; in Pennsylvania Prof. J. P. Lesley has been at the head of the survey for about 20 years; in New Jersey Prof. Geo. H. Cook was in charge from 1863 until his death in 1889; and in Alabama Prof. E. A. Smith has been in service 21 years as the state geologist. It cannot be said that frequent changes in this office are conducive to the best scientific work, for a change in the head frequently results in a change in the subordinates, and when this sweeping change occurs the new incumbents must frequently relearn much that the former officials were perfectly familiar with.

In the present instance, as has occurred before in geological reports, the chief geologist furnishes an introduction to the volume. Here it occupies 8 pages and the remaining 340 are filled by reports from the assistants. Mr. Chas. R. Dryer discusses the geology of Noble and Lagrange counties and the drift of the Wabash-Erie region. W. B. Van Gorder gives a catalogue of the plants of Noble county. Thos. McQuade reports as inspector of mines; N. J. Hyde reports as inspector of oils; E. T. J. Jordan as supervisor of natural gas. Here cognizance is taken of the fact that the supply has been wantonly wasted and recommendations are made for the conservation of the precious fuel. Many of the wells show a decrease in pressure and volume, many others are already exhausted, and the new ones that are being drilled do not show anything like the pressure or volume of the great "gassers" so common at first. E. P. Cubberly discusses the structural features of the state as revealed by the drill in a series of sections made in various directions across the state; and finally S. A. Miller supplies the paleontology.

There was a time when the pages of the Journal of the Cincinnati Society of Natural History were largely used by Mr. Miller in his descrip-

tions of new species, but of late years he has been contributing largely to the publications of the States of Indiana and Illinois. In the present instance he has 100 pages devoted to fossils. This section was issued as a separate in September, 1892, separately paged. There is no mention of this fact in the present volume, which is to be regretted, since there may be in time, when the species come to be referred to, some difficulty about ascertaining the date of first publication. Many persons will see this volume who will not know of the separates, and errors of reference are likely to result. There are 76 new species described, and it is interesting to note that of these less than one-half (36) are from Indiana, most of the others being from Missouri. It is also noticeable that only 12 out of the 76 are in the state museum at Indianapolis, the other types being in the collections of Mr. Miller and other gentlemen who have collected them. J. F. J.

RECENT PUBLICATIONS.

I. *Government and State Reports.*

Iron Ores of North Carolina. By H. B. C. Nitze. North Carolina Geol. Survey, Bull. No. 1, 239 pages, 20 plates, 1893.

Eleventh Annual Report of the State Geologist (N. Y.), for the year 1891, contains: Report of the State Geologist, James Hall: Catalogue of the collection of geological and palæontological specimens donated by the Albany Institute to the State Museum, J. M. Clarke: List of the original and illustrated specimens in the palæontological collections: Part I. Crustacea, J. M. Clarke: On Cordania, a proposed new genus of trilobites, J. M. Clarke: An introduction to the study of the Brachiopoda, intended as a hand-book for the use of students, James Hall, assisted by J. M. Clarke.

Twelfth Annual Report of the State Geologist (N. Y.), for the year 1892, contains: Report of the State Geologist, James Hall; Report of the Assistant Palæontologist, J. M. Clarke; List of the original and illustrated specimens in the palæontological collections: Part II. Annelida and Cephalopoda, J. M. Clarke: Notes upon two boulders of a very basic eruptive rock from the west shore of Canandaigua lake, and their contact phenomena upon the Trenton limestone, B. K. Emerson: The Devonian section of central New York along the Unadilla river, C. S. Prosser.

The Trap Dikes of the Lake Champlain Region. By. J. F. Kemp and V. F. Marsters. U. S. Geol. Survey, Bull. 106, 62 pages, 4 plates, 1893.

The Eruptive and Sedimentary Rocks on Pigeon Point, Minnesota,

and their Contact Phenomena. By. W. S. Bayley. U. S. Geol. Survey, Bull. 109, 121 pages, 8 plates, 1893.

Annual Report of the Smithsonian Institution, 1892, contains: Geological change and time, Archibald Geikie: Geological history of the Yellowstone National Park, Arnold Hague: Soaping geysers, Arnold Hague: Continental problems of geology, G. K. Gilbert: Crystallization, G. D. Liveing; The rejuvenescence of crystals, J. W. Judd.

The relation of biology to geological investigation. By C. A. White. Rept. U. S. National Museum for 1892, pp. 245-368.

Note on a blue mineral, supposed to be ultramarine, from Silver City, New Mexico. By R. L. Packard. Proc. U. S. National Museum, vol. 17, No. 978.

Forty-fifth Annual Report of the Regents of the New York State Museum, for the year 1891, contains: Report on a deposit of marl and peat in the town of New Baltimore, W. B. Marshall: Report on the development of the Salt industry of central New York for the year 1891, I. P. Bishop: also the papers listed under the 11th Report of the State Geologist.

Forty-sixth Annual Report of the same, contains: Papers listed under the 12th Report of the State Geologist.

Twelfth Annual Report of the United States Geological Survey, Pt. I (Geology), contains: Report of the Director, J. W. Powell: Administrative Reports: The origin and nature of soils, N. S. Shaler: The Lafayette formation, W J McGee: The North American continent during Cambrian time, C. D. Walcott: The eruptive rocks of Electric peak and Sepulchre mountain, Yellowstone National park, J. P. Iddings. Part II is devoted to Irrigation.

II. Proceedings of Scientific Societies.

Annals of the N. Y. Academy of Sciences, vol. 7, nos. 6-12, March, 1894, contains: The granite of Mounts Adam and Eve, Warwick, Orange county, N. Y., and its contact phenomena, by J. F. Kemp and Arthur Hollick, with an appendix containing a list and bibliography of the minerals occurring in Warwick township, by Heinrich Ries.

Bulletin of the Geological Society of America, vol. 5, pp. 515-665, contains: Eastern boundary of the Connecticut Triassic, W. M. Davis and L. S. Griswold: Pleistocene problems in Missouri, J. E. Todd: Proceedings of the sixth annual meeting, held at Boston, Dec. 27, 28 and 29, 1893, H. L. Fairchild: Geological writings of Alexander Winchell; Geological writings of Charles Albert Ashburner, F. A. Hill: Geological writings of David Honeyman, J. G. McGregor: Geological writings of George H. Cook, J. C. Smock: Geological writings of Richard Owen, J. Stanley-Brown; Fossil flora of Alaska, Frank H. Knowlton; Johann David Schoepf, and his contributions to North American geology, G. H. Williams; the later Tertiary lacustrine formations of the West, W. B. Scott: Volcanite, an anorthoclase-augite rock chemically like the dacites, W. H. Hobbs: Geographical work for state geological surveys,

W. M. Davis: the ancient strait at Nipissing, F. B. Taylor: Microscopic structure of silicious oölite, E. O. Hovey.

III. Papers in Scientific Journals.

American Journal of Science, 3, vol. 47, May, 1894, contains: Observations on the derivation and homologies of some articulates, J. D. Dana: Crystallization of herderite, S. L. Penfield: Additional note on leucite in Sussex Co., N. J., J. F. Kemp: Phonolitic rocks from the Black Hills, L. V. Pirsson: General structure of the main axis of the Green Mountains, C. L. Whittle: Notes on apparatus for the geological laboratory, J. E. Wolff: Diversity of the Glacial drift along its boundary, Warren Upham: Gases in Kilauea, W. Libby, Jr.: Presence of water in topaz, P. Jannasch and J. Locke: Chemical composition and related physical properities of topaz, S. L. Penfield and J. C. Minor, Jr.: Restoration of Elotherium, O. C. Marsh: New Miocene mammal, O. C. Marsh.

American Journal of Science, 3, vol. 47, June, 1894, contains: Notes from the Bermudas, Alex. Agassiz: Discovery of Devonian rocks in California, J. S. Diller and Chas. Schuchert: Beaver Creek meteorite, E E. Howell, W. F. Hillebrand, and G. P. Merrill: On allanite crystals from Franklin Furnace, N. J., A. S. Eakle: On argyrodite and a new sulphostannate of silver from Bolivia, S. L. Penfield: Notes on the gold ores of California, H. W. Turner: A recent analysis of Pele's hair and a stalagmite from the lava caves of Kilauea, A. H. Phillips.

The Journal of Geology, vol. 2, No. 3, April-May, 1894, contains: The oil shales of the Scottish Carboniferous system, H. M. Cadell; The Cretaceous rim of the Black Hills, L. F. Ward: On Diplograptidæ, Lapworth, Carl Wiman: Geological Surveys in Alabama, E. A. Smith: The superficial alteration of ore deposits, R. A. F. Penrose, Jr.: Studies for students: Erosion, transportation and sedimentation performed by the atmosphere, J. A. Udden.

American Naturalist, June, 1894, contains: A glacial ice dam and a limit to the ice-sheet in central Ohio, W. G. Tight.

National Geographic Magazine, vol. 6, pp. 63-128, May 23, 1894, contains: Geomorphology of the southern Appalachians, C. W. Hayes and M. R. Campbell.

IV. Excerpts and Individual Publications.

The work and scope of the Geological Survey. By C. R. Keyes. Iowa Geol. Survey, vol. III, Ann. Rept. for 1893, pp. 47-98, 1894.

Sketch of the coal deposits of Iowa. By C. R. Keyes. Mineral Resources of the United States for 1892, pp. 138-144, 1893.

Natural gas and oil in Iowa. By C. R. Keyes.

Cretacious formations of northwestern Iowa (abstract). By C. R. Keyes. Proc. Iowa Acad. Sci. for 1893, vol. I, pt. 4, pp. 24, 25.

Derivation of the Unio fauna of the northwest. By C. R. Keyes. Proc. Iowa Acad. Sci. for 1893, vol. I, pt. 4, pp. 26-29.

Vertebrata from the Neocomian of Kansas. By F. W. Cragin. Fifth Annual Publication of the Colorado College Scientific Society; 4 pages, 1894.

Structure of the Mystic coal basin. By H. Foster Bain. Proc. Iowa Acad. Sci. for 1893, vol. I, pt. 4, pp. 33-36.

Sigourney deep well. By H. Foster Bain. Proc. Acad. Sci. for 1893, vol. I, pt. 4, pp. 36-38.

Muir Glacier. By S. P. Baldwin. The Lehigh Quarterly, vol. II, no. 1, pp. 3-12, Jan., 1892.

Notes on the lower strata of the Devonian series in Iowa. By W. H. Norton. Proc. Iowa Acad. Sci. for 1893, vol. I, pt. 4, pp. 22-24.

The zinc-ore-deposits of southwestern New Mexico. By W. P. Blake. Trans. Amer. Inst. Mining Engineers, Virginia Beach meeting, Feb., 1894; 9 pages.

Memoir of Ferdinand Vandiveer Hayden. By C. A. White. National Acad. Sci., pp. 395-413, 1894; with portrait.

Additions to the palæontology of the Cretaceous formation on Long Island. By Arthur Hollick. Bull. Torrey Bot. Club, vol. 21, pp. 49-65, 7 plates, Feb. 1894.

Some furthur notes on the geology of the north shore of Long Island. By Arthur Hollick. Trans. N. Y. Acad. Sci., vol. 13, pp. 122-132, 1894.

The Rensselaer grit plateau in New York. By T. Nelson Dale. 13th Ann. Rept., U. S. Geol. Survey, pp. 291-340, pls. 97-101, 1894.

Facetted pebbles on Cape Cod, Mass. By W. M. Davis. Proc. Boston Soc. Natural History, vol. 26, pp. 166-175, 2 plates.

A summary of progress in mineralogy and petrography. By W. S. Bayley. From monthly notes in the American Naturalist: Geological Dept., Colby University, Waterville, Me., 1894; price 50 cents.

An orbicular granite from Quonochontogue Beach, Rhode Island. By J. F. Kemp. Trans. N. Y. Acad. Sci., vol. 13, pp. 140-144, pl. 2, 1894.

Notes on the Lower Coal Measures of western Clearfield county, Pennsylvania. By J. F. Kemp. School of Mines Quarterly, pp. 349-353, July, 1893.

A Pleistocene lake-bed at Elizabethtown, Essex county, New York. By Heinrich Ries. Trans. N. Y. Acad. Sci., vol. 13, pp. 107-109, Nov., 1893.

The old Telegraph mine, Bingham Cañon, Utah. By Clarence Fenner. School of Mines Quarterly, pp. 335-360, July, 1893.

Illustrations of the fauna of the St. John group, No. VIII. By G. F. Matthew. Trans. Royal Soc. Canada, Sec. IV, 1893, pp. 85-129, 2 plates.

Growth of Iowa's coal industry. By C. R. Keyes. Iowa Weather and Crop Service, vol. IV, no. 12, pp. 5-7, Dec., 1893

What the Iowa Geological Survey has been doing. By C. R. Keyes. Iowa Weather and Crop Service, vol. V, no. 1, pp. 4-7, Jan., 1894.

The geological mapping of Iowa. By C. R. Keyes. Iowa Weather and Crop Service, vol. V, no. 2, pp. 4-6, Feb., 1894.

Southern extension of the Cretaceous in Iowa. By E. H. Lonsdale. Proc. Iowa Acad. Sci. for 1893, vol. I, pt. 4, pp. 39-43.

Topography of the granite and porphyry region of Missouri. By E. H. Lonsdale. Proc. Iowa Acad. Sci. for 1893, vol. I, pt. 4, pp. 43-48.

Process of formation of certain quartzites (abstract). By C. R. Keyes. Proc. Iowa Acad. Sci. for 1893, vol. I, pt. 4, pp. 29-31.

Iowa gypsum deposits. By C. R. Keyes. Iowa Weather and Crop Service, vol. IV, no. 3, pp. 2-4, March, 1893.

The geology of the proposed tunnel under the Northumberland Strait. By R. W. Ells. Trans. Royal Soc. Canada, Sec. IV, 1893, pp. 75-84.

Popular Lectures and Addresses. By Sir William Thomson (Baron Kelvin). Vol. II. Geology and General Physics. 599 pages, 12mo: Macmillan & Co., 1894; price $2.

V. *Foreign Publications.*

Sveriges Geologiska Undersökning, Ser. C, Afhandlingar och Uppsatser, contains: No. 112, Sveriges kambrisk-Siluriska Hyolithidæ och Conulariidæ (with an English summary), pp. 1-169, 6 plates, Gerhard Holm: No. 116, Om kvartsit-sparagmitområdet i Sveriges sydliga fjelltrakter, pp. 1-20, A. G. Högbom: No. 117, Bidrag till kännedomen om de glaciala företeelserna i Norrbotten, pp. 1-38, 1 map, K. A. Fredholm: No. 118, Skotska byggnadssätt för naturlig sten, pp. 1-16, 1 plate, Hjalmar Lundbohm: No. 219, Agronomiskt botaniska studier i norra Dalarne åren 1890 och 1891, pp. 1-60, A. G. Kellgren: No. 120, Untersuchungen über fossile Hölzer Schwedens, pp. 1-99, 11 plates, H. Conwentz: No. 121, Om mynningen hos Lituites, pp. 1-46, 3 plates, Gerhard Holm; No. 122, Mëddelanden om jordstötar i Sverige, II, pp. 1-22, E. Svedmark: No. 123, Anteckningar från en i praktiskt syfte företagen geologisk resa i Vesterbottens lån, pp. 1-14, Albert Blomberg; No. 124, Studier öfver de glaciala aflagringarna i Upland, pp. 1-24, 1 plate, A. G. Högbom: No. 125, Om skiffern med Clonograptus tenellus, dess fauna och geologiska ålder, pp. 1-16, 1 plate, J. C. Moberg: Om en nyupptäckt fauna i block af kambrisk sandsten, pp. 1-18, 1 plate, J. C. Moberg: Om några nya graptoliter från Skånes undre graptolitskiffer, pp. 1-18, 1 plate, J. C. Moberg: Till frågen om pygidets byggnad hos Ctenopyge pecten, pp. 1-5, J. C. Moberg: Om dem af Trinucleus coscinorrhinus Ang. karakteriserade kalkens geologiska ålder, pp. 1-4, J. C. Moberg: No. 126, Om berggrunden i Norrbottens lån och utsigterna till brytvärda apatitförekomster derstädes, pp. 1-43, 1 map, Fredr. Svenonius; No. 127, Apatitförekomster i Norrebottens malmberg, pp. 1-38, Hjalmar Lundbohm: No. 128, Om märken efter isdämda sjöar i Jemtlands fjelltrakter, pp. 1-22, 2 plates, A. J. Högbom: Om interglaciala aflagringar i Jemtland, pp. 1-17, A. G. Högbom: No. 129, Om stenindustrien i Förenta staterna, pp. 1-32, Hjalmar Lundbohm: No. 130, Bidrag till kännedomen om lagerföljden inom den kambriska sandstenen, pp. 1-17, N. O. Holst: No. 131, Praktisk geologiska undersökningar inom Hallands län: Beskrifning till geologisk jordartskarta ofver Hallands lån, Gerard De Geer, J. Jönsson, P. Dusén and Th. Palmberg: Beskrifning öfver berggrunden inom Hallands lån, pp. 1-16, E. Svedmark: No. 132, Om Berggrunden i Vesternorrlands kusttrakter, pp. 3-8, Hjalmar Lundbohm: Om postarkäiska eruptiver inom det svenskfinska urberget, pp. 9-40, 1 plate, A. G. Högbom: Om de s. k.

urgraniterna i Upland, pp. 41-74, A. G. Högbom: No. 133, Om de porfyriska gångbergarterna i östra Småland, pp. 1-28, Otto Nordenskjöld; No. 134, Om hasselns forntida och nutida utbredning i Sverige, pp. 1-32, Herman Hedström.

The Glacialists' Magazine, vol. 1, no. 7, Feb., 1894, contains: Sections in the drift at Shelton, Hanley, F. Barke: The cause of the ice age, abstract of paper by Marsden Manson: The great submergence, Edward Hull.

Mathematische und naturwissenschaftliche Mittheilungen aus den Sitzungsb. der k. preussischen Akad. der Wissens. zu Berlin, Heft viii, Oct., 1893, contains: Die Gliederung der ober Kreide in Friaul, Karl Futterer.

The same, Heft ix, Nov. 1893, contains: Sulfoborit, ein neues krystallisirtes Borat von Westeregln, H. Bücking.

The same, Heft x, Dec. 1893, contains: Ueber die Gliederung der Flötzformationen Helgolands, W. Dames: Mittheilungen zur Kenntniss der regulär krystallisirenden Substanzen, Ludwig Wulff.

Viertel jahrsschrift der Naturforschenden Gesellschaft in Zürich, Jahrg. 38, Heft 3-4, 1893, contains: Ueber Neocomian-Versteinerungen aus dem Somali-Land, C. Mayer-Eymar.

Zeitschrift der Gesellschaft für Erdkunde zu Berlin, Band 38, 1893, No. 5, contains: Devonische Versteinerungen von Lagoinha in Mato Grosso (Brasilien), Ludw. v. Ammon.

On the sequence of perlitic and spherulitic structures, a rejoinder to criticism, Frank Rutley. Quart. Journ. Geol. Soc., vol. 50, pp. 10-14, 1 plate, 1894.

Anales del Museo Nacional de Montevideo, I, 1894, contains: Memoria geológica sobre la formación del Rio de la Plata, D. A. Larrañaga.

Bulletin de la Société des Sciences Naturelles de l'Ouest de la France, Tome 3, No. 4, contains: Additions a la flore éocène du Bois-Gouët, Ed. Bureau and N. Patouillard: Notice explicative de la Feuille géologique de Vannes, Ch. Barrois.

Bulletin de la Société Géologique de France, 3 Sér., T. 21, 1893, No. 2, contains: Note sur les phénomènes de recouvrement des environs de Toulon, Ph. Zürcher: Recherches sur le Lepidodendron selaginoides, Sternb., Maurice Hovelacque: Sur le Tertiaire supérieur de l'Algérie, M. Peron: Allocution présidentielle, Michel Lévy: Rapport sur le prix Fontannes, Marcel Bertrand: Note sur un gite cuivreux d'origine volcanique du Caucase méridional, M. Chaper: Notice géologique sur les environs de Menton, G. Baron: Note sur les genres Trillina et Linderina, C. Schlumberger: Sur le Permien du massif de la Vanoise, P. Termier: Le Quaternaire du maz d'Azil, M. Tardy.

The same, 3 Sér., Tome 21, 1893, No. 4, contains: Sur un gisement d'ammonites dans le Lias calcaire de l'Oisans, P. Termier and W. Kilian: Sur la géologie des environs de Bugarach et la craie des Corbières, A. de Grossouvre: La fauna de Pikermi a Ambérieu (Ain), M. Boistel: Sur le gisement et la signification des fossiles Albiens des Pyrénées occidentales, M. Stuart-Menteath: Note sur le Cambrien de l'Hé-

rault (Cambrian anglais). P. G. de Rouville: Notes paléontologiques. J. Bergeron.

Geologiska Föreningens i Stockholm Förhandlingar. Band 16, No. 155, Jan., 1894, contains: Om biologisk undersökning af leror o. s. v., Henr. Munthe: Om nordvästra Kamerunområdets geologi. P. Dusén.

The same. Band 16, No. 156, Feb., 1894, contains: Knopit, ett perowskit närstående, nytt mineral från Alnön, P. J. Holmquist: Flottholmen i sjön Ralången, Victor Öberg: Tvänne nyupptäckta svenska klotgraniter, Helge Bäckström: Gångformiga malmbildningar i Norrbotten, G. Löfstrand: Om kentrolit och melanotekit, G. Nordenskiöld.

Zeitschrift für praktische Geologie, March, 1894, contains: Geologische Specialaufnahme von Italien, Augusto Stella: Die Zink- und Bleierzbergbaue bei Rubland in Unter-Kärnten, R. Rosenlecher: Setze die Saarbrücker Steinkohlenformation unter dem pfälzischen Deckgebirge fort?, L. Rosenthal.

Natural science in Japan. By F. A. Bather. Natural Science, vol. IV, pp. 19-26, 98-111, 183-193.

Notes on the occurrence of mammoth-remains in the Yukon district of Canada and in Alaska. By G. M. Dawson. Quart. Jour. Geol. Soc., vol. I. Feb. 1894, 9 pages.

Lunds Universitets Års-Skrift, tom. XXIX, 1892-93, contains: Observations on the structure of some Diprionidæ, Sv. Leonh. Törnquist.

The Geological Magazine, April, 1894, contains: On the structure and affinities of the genus Solenopora, together with descriptions of new species, Alex. Brown: On the sand-grains in micaceous gneiss from the St. Gothard tunnel, and on some other difficulties raised by Prof. Bonney, F. M. Stapff: The Mammoth age was contemporary with the age of the great glaciers, H. H. Howorth: Further remarks on the Tertiary (Eocene) insects from the Isle of Wight, and on others from the Lias and Coal-Measures, P. B. Brodie: Cordierite in the Lake district, Alfred Harker: Jurassic ammonites, notes on a pamphlet by Dr. Emle Haug, S: S. Buckman: Preservation of fossil plants, A. C. Seward: The great Japanese earthquake, Joseph Prestwich.

Report on Mount Morgan gold deposits. By R. L. Jack. Reprinted for the Mount Morgan Mining Company, Limited, from an official report ordered by the Legislative Assembly to be printed, Nov. 21, 1884.

VI. Proceedings of Scientific Laboratories, etc.

The Kansas University Quarterly, vol. 2, No. 3, Jan., 1894, contains: Report on field work in geology for the season of 1893, by the department of physical geology and mineralogy, University of Kansas (Prefatory notes, E. Haworth: Relative value of limestone, sandstone and shale for stratigraphic work in Kansas, E. Haworth: A geological section along the Neosho river from the Mississippian series in the Indian Territory to White City, Kansas, and along the Cottonwood river from Wyckoff to Peabody, E. Haworth and M. Z. Kirk: A geologic section along the Verdigris river from the state line to Madison, E. Haworth and W. H. H. Piatt: A geologic section along the A. T. & S. F. R. R. from Cherryvale to Lawrence, and from Ottawa to Holoday, E. Haw-

orth: Resumé of the stratigraphy of eastern Kansas. E. Haworth: The topography of eastern Kansas. E. Haworth: Surface gravels in eastern Kansas. E. Haworth). A geological reconnoissance in southwestern Kansas and No Man's Land. E. C. Case: Traces of a glacier at Kansas City, Mo., E. C. Case: New genera and species of Dolichopodidae. J. M. Aldrich: Descriptions of North American Trypetidae, with notes. Part I. W. A. Snow.

The School of Mines Quarterly, vol. 15, no. 2, Jan., 1894, contains: Acanthite from Colorado. A. H. Chester: Index to mineralogical literature. A. J. Moses and L. McI. Luquer.

Johns Hopkins University Circulars, vol. 13, No. 112, May, 1894, contains: On the attractions of crystalline and isotropic masses at small distances (abstract). A. S. Mackenzie: Notes on crystals of scapolite, gypsum and fayalite recently acquired by the University cabinet. G. O. Smith: Note on an apatite crystal from Alexander county, N. C.. L. M. Prindle.

CORRESPONDENCE.

TRILOBITES IN THE "OIL-ROCK" HORIZON OF THE TRENTON LIMESTONE. The Upper Blue limestone member of the Trenton group in the lead region of Wisconsin is generally highly fossiliferous. There are, however, considerable local differences in the grouping of genera and species, and especially as to quantity and condition of preservation. At one of the mines of lead and zinc ore of the Wisconsin Lead and Zinc Company in the township of Shullsburg, Lafayette county, I have recently found several species of trilobites in a remarkably good state of preservation, and showing details of structure not usually seen. Thus, aside from the interest attaching to the discovery of so many of these organisms in close association with lead and zinc ores, the locality promises to afford valuable material to the specialists who are now investigating the structure of trilobites, and who have of late so greatly extended our knowledge of it.

The genus *Ceraurus* is the most frequently represented. In most of the specimens the shell remains in the rock, but in an extremely soft and fragile condition, white and chalk-like, much resembling egg shell, but not so hard or tough.* But all the minute details of the shell are well preserved and may be seen not only upon the shell, when it can be saved, but upon the casts in the rock, both above and below. It is not possible to obtain complete individuals, but in breaking up the rocks where many of the fossils are grouped together some fragments exhibit one portion and some another, so there is little difficulty in making out the entire structure.

The cephalic portion of *Ceraurus* is the most abundant. There ap-

*Fragments are rapidly dissolved with effervescence by hydrochloric acid.

pear to be two species: one of them is probably *C. pleurexanthemus*: the other species, which remains undetermined, is smaller and less abundant. It is not certain to which of these species the caudal spines found associated with them should be referred.

There are two other trilobites: one is a small species, apparently a *Dalmania*, of which the pygidium alone is found: and the other is supposed to be a species of *Encrinurus*, also in fragments. Another form differs from any described in the Wisconsin reports, being less rotund and showing the three lobes by slight depressions in the smooth surface of the pygidium. The outline is parabolic. The axial or medial lobe is fully one-third of the breadth, anteriorly, but it tapers rapidly posteriorly, with the sides incurved. This axial lobe is only slightly convex, but the lateral lobes slope downward steeply toward the margin, thus presenting an outline in cross-section very different from any figured in the Wisconsin reports. Possibly these should be referred to *Asaphus*. The form of some of the fragments of the cephalic shield favors this view.

Amongst the other associated fossils in a good state of preservation are two or three species of *Orthis* and *Murchisonia*; one of *Orthoceras*; *Cypricardites*, *Raphistoma*, *Hyolithes*, *Streptelasma*, and encrinal stems. These may not all be from one stratum, but they are thrown out from the same mine and are at least in neighboring layers and contiguous to a deposit of galena in a layer with calcite in a blue clay. The horizon of all the fossils is the "oil-rock" or bituminous shale series of thinly bedded limestones, at the top of the Blue limestone of the Trenton and at the base of the Galena dolomite.

I have not been able to find any traces of antennæ in connection with the trilobites. There are many obtuse conical fragments, beautifully facetted, supposed to be the eyes of the species here referred provisionally to *Encrinurus* or *Asaphus*, supported on gracefully shaped peduncles rising from the smooth surface of thin plates.

The specimens I have collected need examination by competent authority, and it will give me pleasure to submit the collection to any specialist who will undertake to describe the species for publication.

WM. P. BLAKE.

Helena Mill, Shullsburg township, Wisconsin, June 20, 1894.

THE ROCK BASIN OF CAYUGA LAKE. A paper on this subject by Prof. R. S. Tarr, was read before the Geological Society last December, and is published in the Bulletin of the Society. As it touches upon my investigations, I have a word or two of comment at present. He bases his conclusions on certain lateral phenomena, and compares the former slope of the drainage with the present lake level. In this paper he says that the greatest depth of the lake is 435 feet, being near the southern end. Now, Mr. McGee has shown that the late terrestrial deformation along the upper Susquehanna river is three feet to the mile to the north. I have shown the same to occur in the Niagara district, and Mr. Gilbert and myself have shown this or greater amounts at the eastern end of

lake Ontario. Prof. Tarr ignores this tilting, yet it has backed the Cayuga water to a depth of over 100 feet at the southern end of the lake. Therefore his data for comparing the ancient slope of the valley will not stand. With this warping removed, the lake would be reduced to a maximum depth of about 300 feet. I have been informed by well-borers that north of the lake they have penetrated to a depth of 200 and 300 feet without reaching rock. This statement I do not think Prof. Tarr has denied. Under these conditions there is no known rock basin at all, to have been excavated by glaciers. If his evidence of glacier erosion holds good, he must amend his thesis to glacial "erosion of valleys" and not "basins."

Prof. Tarr also concludes that lake Ontario may be a rock basin, because he thinks Cayuga basin to be one. This I am willing to concede, although his present proofs do not make it sure that lake Cayuga occupies a rock basin. But again let me call attention to the fact that in places the St. Lawrence river channel is filled with drift to a depth of 240 feet, so that the nearest rocky barrier closing the lake is only 500 feet above the deepest sounding of the lake. Now the recent warping of the earth's crust in this region far more than accounts for such a barrier. Consequently, when the cause of a barrier is known, and can be demonstrated as often as necessary, there is no need to appeal to the glacial excavation of the basin, even if the old valley had been channelled by ice, the course of which was oblique to the southern walls of the lake. J. W. SPENCER.

July 5th, 1894.

THE AGE OF NIAGARA FALLS. This note is written simply as a protest against anyone forming a conclusion as to my work on the history of the great lakes, or forming judgments of the history of the lakes themselves, upon the strength of Mr. Upham's citations (AM. GEOLOGIST, July, 1894) from my writings. It was I who first surveyed the Algonquin beach and found that it proved that there was no connection at that time with the Erie basin, but that there was a northeastern outlet. From the present outlet of the lake I surveyed this beach for about 500 miles, and in my papers I not only stated that the Algonquin beach crossed what is now the outlet of lake Huron below the present lake surface, but also mapped it. Yet Mr. Upham now says: "Careful study of Prof. J. W. Spencer's maps .... of the Huron and Erie shore lines convinces me that the outflow of lake Algonquin at the time of the Nipissing beach went by way of the present St. Clair and Detroit rivers....." The very opposite is shown in my papers, and, if not, field observation not only of the Algonquin but several lower beaches would show the northern outlet adopted by Gilbert and myself, who were the first observers in the region.

This is not the first time that I have had reason for replying to Mr. Upham when using my work, although it is the first time I offer a printed criticism. His method of reasoning is *a priori* to maintain that the discharge of the Niagara has always been equal to that of the present,

against which he can find plenty of proof in the field. He also writes of the Chicago outlet of the great lakes, and here again, had he studied my papers, he would have seen that several beaches are lower than the present surface of the head of lake Michigan,—submerged, in short,—at levels higher than the drowned Algonquin or Nipissing beach (as he calls it). Also he says that seven-eighths of the Algonquin uplift in the Nipissing region took place before the birth of Niagara. I should like to know the grounds for this calculation, for my computations, based on the actual surveys of beaches show that only one-fifth of that uplift was before the birth of Niagara, and that the age of the Niagara falls is indicated to be about 32,000 years. Mr. Upham's paper is misleading, so far as anything I have done in surveys of the lakes is concerned; but I dislike to criticise any writer, and especially before all the results are published, for there are other phenomena that cannot be explained away by *a priori* reasoning.

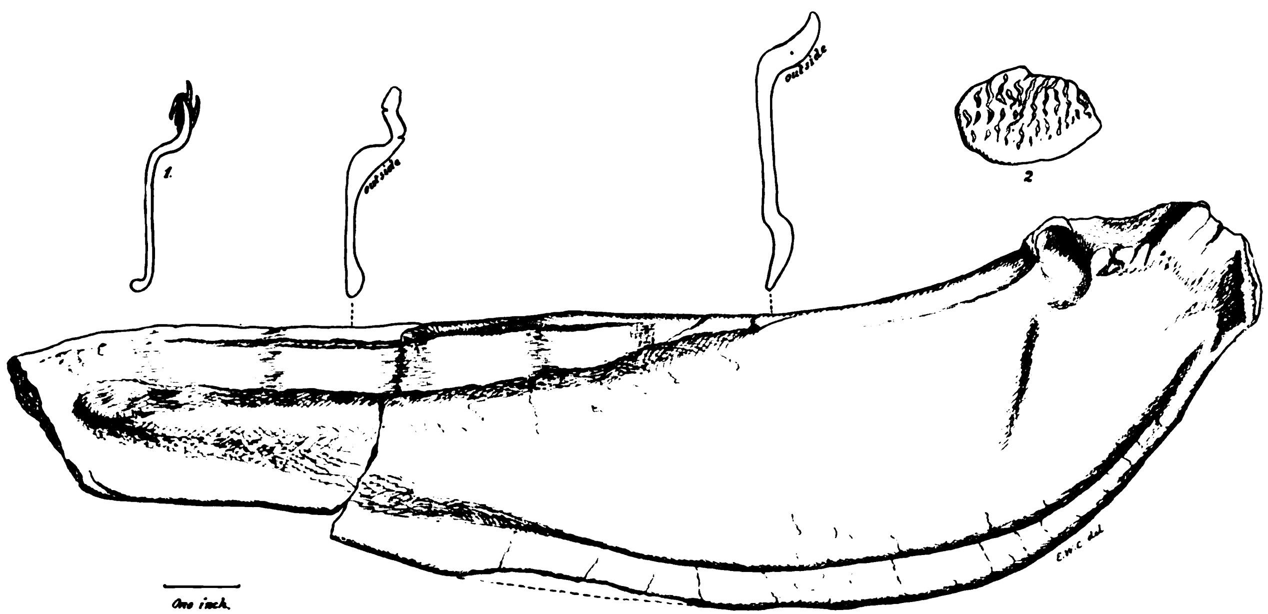
One word more: around the northeastern flanks of the Adirondacks beaches extend at high levels into the Champlain valley (and contain no shells). The position of these beaches disproves any glacial dam at that locality. J. W. SPENCER.

July 5th, 1894.

PERSONAL AND SCIENTIFIC NEWS.

GEORGE HUNTINGTON WILLIAMS, Professor of Inorganic Geology in Johns Hopkins University and vice president of the Geological Society of America, died of typhoid fever at his father's house, Utica, N. Y., July 12th; aged 38. Prof. Williams graduated from Amherst in 1878 and studied under Rosenbusch at Heidelberg, where he took the degree of Doctor of Philosophy in 1882; the next year he became connected with Johns Hopkins and was associate professor there from 1885 to 1892 when he was appointed to the chair he held at his death. A number of the younger geologists of the country have studied under him and to them, as well as to all who knew him, the news of his death comes with special sadness. In an early number of the GEOLOGIST we hope to give a more extended account of the life and work of Prof. Williams, who, both by his publications and his teaching, has done more than any other individual to advance the knowledge of petrography in America.

AT THE KANSAS STATE UNIVERSITY the whole subject of stratigraphic and physical geology has been assigned to Prof. Haworth, leaving only paleontology to Prof. Williston. A collecting expedition to the "bad lands" of Dakota has been made under the direction of Prof. Williston.



1. Section of jaw of recent Shark.

Cladodus magnificus Claypole.
Right Ramus of Lower Jaw — Inside View.

2. Scute of Cl. mag. ?

CLADODUS? MAGNIFICUS, A NEW SELACHIAN.

THE

AMERICAN GEOLOGIST.

VOL. XIV. SEPTEMBER, 1894. No. 3.

[PALEONTOLOGICAL NOTES FROM BUCHTEL COLLEGE.—NO. 7.]

CLADODUS ? MAGNIFICUS, A NEW SELACHIAN.

By E. W. CLAYPOLE, Akron, Ohio.

(PLATE V.)

Among the latest discoveries which have rewarded the persistent search of the veteran collector, Dr. Clark, is a jaw, or rather, a pair of mandibles whose characters are remarkable enough to deserve description, even though we at present know almost nothing, except by inference, of the animal which it represents.

I have figured the inner surface of one of these in the accompanying plate. The other is, unfortunately, broken across and incomplete, yet abundantly sufficient for recognition. They were found lying almost free on the surface of a slab of shale, in the valley of the Rocky river on the same horizon—the Cleveland shale—that has already yielded us so many kindred fossils.

The right ramus, which is the best preserved, and whose inner face is here figured, will form the basis of the following description. So far as it affords characters, these are clear and determinate, but, unfortunately, no trace of teeth was found, so that it is not possible to affirm whether or not the jaw belongs to a cladodont fish.

It is of very large size, measuring fifteen inches in length by three inches and a half in greatest depth. It is a flat, thin plate of bone corrugated along the edge, but generally not exceeding one-eighth of an inch in thickness, though in places it may be double this. A well marked but shallow fossa for the reception of the condyle is present, which faces slightly inward as well as upward. In front of this and behind it are processes for the attachment of the connecting ligaments,

much resembling those which may be seen on the jaws of the existing sharks. From the hindmost point and along the lower edge runs a strong corrugation, formed rather by a folding than by a thickening of the bony plate, and this extends forward at least two-thirds of the length of the jaw and gradually fades away. Outside of this and on the same inner face is a furrow corresponding to a strong ridge on the outer side, extending forward in the same manner and to about the same extent.

The upper edge, however, shows the most obvious characters. At a point about one-third from the hinder extremity commences a strong shelf or corrugation in the bony plate on its inner face, which is equally conspicuous on the outer side and may be well seen in the two sections given in the plate. The outer wall of this shelf has been crushed in to a small extent, but not so as in any way to disguise its form. Evidently it was the base on which was set the epithelial membrane that carried the teeth, and the recess in the jaw above the horizontal shelf served the same purpose as the similar recess in the jaw of an existing shark, to protect the young teeth and to keep them out of the way of the functional ones. The close resemblance between the two, Devonian and recent, may be seen by looking at the section of the latter given in the plate where the teeth are shown in place.

The symphysial articulation is distinct, about one inch and a half in length, straight and retreating below.

There are in the perpendicular wall of the dentiferous margin of the jaw six or seven very slight undulations or recesses of the bone which may and probably do mark the position of as many series of immature teeth. In that case the teeth must have been of large size and distant. Probably they were both. The intervals average about one inch each, but the vertical wall is rather less than an inch high. The teeth were therefore limited in hight to probably about an inch.

The reference of this fossil to *Cladodus* is of course provisional in the absence of teeth. But its general structure establishes its selachian affinity, and its resemblance in general to other fossils from the same stratum warrants a cladodont association, at least for the present.

The only other fragment which was found in close proxim-

ity to it was a small bony plate or scute, represented in the figure, nearly two inches in length by one inch wide, with vermiculated surface and evidently external. If this is really a part of the same fish, as seems highly probable, it indicates a much coarser dermic armor on at least a part of the animal than the ordinary shagreen of the sharks; but in the existing uncertainty on this point it would be useless to pursue it further.

Taking the present fossil in connection with its related forms which have been described in previous numbers of the AMERICAN GEOLOGIST, we can gather one or two important facts in regard to the fishes of the Devonian era in Ohio. While their kinship with the existing sharks is obvious, they yet show considerable difference. In the first place, the position of the mouth is strikingly different, so much so as to deprive them of the very peculiar and characteristic aspect which we associate with the shark at the present time. The mouth in all the recent genera is not terminal but occupies a position considerably behind the snout on the ventral surface, indicating on the part of the animals a habit of feeding on the ground or on prey that lies below them. So marked is this feature that, as is well known, the shark cannot seize an object on the top of the water or above it without turning belly-upward. But the Devonian sharks, at least the cladodonts, had a terminal or nearly terminal mouth, as indicated plainly in the fossils, and were not therefore specially adapted for ground-feeding. In a few specimens the mouth appears to be slightly ventral. In the second place, the jaws of existing sharks are strongly curved and twisted, the upper often forming a complete semicircle, whereas those of the Cladodonts from the Devonian of Ohio are straight and flat, and, so far as known, the upper jaw was of a similar form.

It is not necessary to contrast the narrow elongated phase of the tooth of the recent forms with the wide though one-sided base of those of *Cladodus*, since it is well known to every ichthyologist.

If we may infer the size of the fish to which the fossil here described belongs, from the analogy with other Ohio cladodonts, we may safely predicate a shark not less than ten feet, and probably more, in length. So far it is by much the larg-

est of its family that has come to light, the longest previously known scarcely exceeding one-half of this size. Dr. Clark is, however, in possession of one or two cladodont teeth too large to correspond with the dimensions of the smaller specimens, which have for some time indicated to him the existence of larger forms hitherto unknown, the first of which is described in this note.

These researches and discoveries have established the existence of an abundant selachian fauna in the Cleveland shale, with the general form of which we are now much better acquainted than we are with those later ones from the Carboniferous limestone whose spines and teeth have long been abundant in our museums, but of which themselves we have yet but the merest glimpse in one or two ill preserved specimens in European collections.

THE NIOBRARA CHALK.*

By Samuel Calvin, Iowa City, Iowa.

CONTENTS.

It was my original purpose to take for the subject of this discourse some geological problems in northeastern Iowa, but certain circumstances made it seem more desirable to transfer attention to the northwestern part of the state and discuss the more striking features of the Niobrara chalk.

*Vice-presidential address before the section of Geology and Geography, American Association for the Advancement of Science, August 16, 1894.

The Niobrara stage of the Upper Cretaceous is well represented along the Missouri from the mouth of the Niobrara river to the mouth of the Big Sioux. East of the Sioux, beds of the same stage are found at various points in Iowa as far eastward as Auburn in Sac county,* while fossils distributed through the drift indicate the former existence of Cretaceous strata at points many miles farther east than any localities where they are now known to occur in place.†

Areal Distribution.

The general distribution of the Niobrara deposits, it need not be said in this presence, covers an area reaching from western Iowa to the Rocky mountains, while north and south it stretches from Texas to Manitoba and probably northward to the Arctic ocean. It is not my intention to extend the discussion of the formation so as to cover more than a very small fraction of this magnificent area. I purpose rather to limit myself to some of the characteristics of the Niobrara chalk exhibited in the somewhat restricted region lying between the mouth of the river from which the formation takes its name and the most eastern exposure of the beds at present known, near Auburn, Iowa. Within these rather narrow limits all the typical phases of the Niobrara formation are perfectly exemplified, and ample facilities are afforded for the satisfactory study of its composition. Furthermore, it will be remembered that the shore line of the Niobrara sea passed through Iowa, and during the culmination of the conditions that gave us the peculiar deposits of this portion of geological time the sea margin was probably not very far east of Auburn. Indeed it may be shown that the shore line was subject to many movements of advance and retreat, and that during the early part of the Niobrara age the sum of the movements was eastward and the ocean gradually encroached upon the land; while later the reverse was true and the waters retreated toward the west. For these reasons the region to which the discussion is limited affords facilities for determining the effects of varying depths of water and varying degrees of proximity to the shore upon the composition and origin of its sedimentary de-

*C. R. Keyes, Proceedings Iowa Acad. Sci., Vol. I, part IV, p. 25, 1894.

†C. A. White, Proceedings A. A. A. S., Vol. 21, p. 187, 1872.

posits. In the eastern part of the region we may look for marginal beds of Niobrara age, and farther west we should find contemporaneous beds that accumulated off shore in the clear open sea.

PHYSICAL CHARACTERISTICS.

The Niobrara sediments are unique among the geological formations of the Northwest. Where typically developed they are wholly calcareous, or nearly so, and yet they are altogether unlike the limestones that are so common and so characteristic a feature of the geology of the upper part of the Mississippi valley. They lie indeed in massive strata, varying from six inches to more than two feet in thickness, as do some of the limestones, but the material is chalky in appearance and correspondingly soft in texture. The color of freshly exposed surfaces varies from white through shades of gray and yellow. In some instances the weathered surfaces become reddish owing to the final oxidation of the small amount of iron which the beds contain. The material composing what anyone studying the region under consideration would call the typical deposits, may be excavated with pick and spade; it may be carved with the pocket knife; the massive blocks into which the layers are readily quarried may be shaped with the saw with greater ease even than if they were blocks of wood; the material is so soft, indeed, that it cannot be handled without soiling the fingers; it may be used for writing on the blackboard; the mechanic might use it on his chalk lines; in a word, these typical beds to which our attention will be chiefly directed are nothing more nor less than chalk.

It is not to be understood, however, that all the Niobrara deposits of our somewhat circumscribed region are chalky. Some would have to be described as soft calcareous shales, while others are made up of thin-bedded, fissile limestone, sometimes more or less earthy and impure, but composed chiefly of valves of *Inoceramus problematicus* cemented together. It is only the beds that represent what we may call the perfect and ideal product of the conditions that prevailed during Niobrara time that are massive, soft and chalky.

STRATIGRAPHICAL AND BATHYMETRICAL RELATIONS.

Allow me to traverse familiar ground long enough to say that the Niobrara chalk is a part of the Missouri Cretaceous

series that was long ago made classic by the labors of Meek and Hayden. The work of Hill and others in Texas enables us now to refer the beds in question to the Upper Cretaceous, as distinguished from the Comanche or Lower Cretaceous series of the Southwest. In the region we are considering the Cretaceous begins with the Dakota sandstone, a formation indicative of shallow seas and moderately high contiguous shores. During the deposition of the Dakota beds the water over what we now call Sioux City was shallow and vexed sometimes with conflicting currents, as is shown by the cross-bedded sands with oblique planes inclined in many different directions. That the land was high enough to enable the drainage waters to carry coarse mechanical sediments, that it was covered with semi-tropical forests of deciduous trees, and that its surface was watered with a most generous rainfall, are clearly recorded in the material composing the deposits, in the taxonomic relations of the leaves and other organs that make up the profusion of fossil plants which some of the beds contain, and in the brackish-water types composing the rather meager molluscan fauna of the earlier layers. Moreover the region was part of a great area of subsidence. If we limit attention to some given point, for example the bluffs above the mouth of the Sioux river, we shall find certain facts clearly recorded. During the entire time represented by the Upper Cretaceous there may have been many alternations of elevation and subsidence, but at first the waters were gradually deepened and the shore line became more and more remote. As these processes went forward the coarser sediments, together with the leaves and twigs of the magnificent forest flora clothing the land, all came to rest in the beds laid down near the constantly receding shore, and only the finer clays were carried seaward as far as the point we have selected for consideration. With progressive subsidence the land stood lower, the drainage streams became more sluggish, erosion was less energetic, and it is probable that at this stage even in the marginal sediments the materials were fine clay with little admixture of siliceous sand. At all events, at a short distance from the shore we have the transition from Dakota sands, with some alternating beds of shales, to the purer Fort Benton clays, which represent the second phase of sedimenta-

tion in our selected area during Cretaceous times. The Benton shales are not very thick in this region, probably not more than 40 feet altogether. While they were accumulating the process of subsidence went on, as before, at a rate more rapid than the upward growth of the sedimentary deposits. The lands, that during the Dakota stage had stood high above the sea, were by progressive subsidence reduced in altitude until finally base level was reached, and the sluggish drainage streams discharging into this part of the Cretaceous basin failed to carry even the finer clay and at last mechanical sediments gave place to those of organo-chemical origin. When these conditions were reached, the region witnessed the beginning of the third phase of sedimentation in the Cretaceous seas, and the Niobrara stage, with its peculiar beds of chalk, was inaugurated. Reviewing for a moment the conditions prevailing in that portion of the region that now lies west of the Sioux river, we may note that the water was clear, moderately deep, and unpolluted by mechanically derived earthy detritus; that the shore line, a portion of the time at least, was a hundred miles to the eastward; that the body of land contiguous to the shore was low and flat, and drained by streams with currents too feeble to bear any contributions from the land to the sea. It was in such a sea and under such conditions that the Niobrara chalk was deposited.

Before the Niobrara age came to a close, the upward movement of the region began. Step by step the sea receded from its line of farthest advance, somewhere east of the middle of Iowa. Progressive elevation of the land quickened into life the practically dead streams of the Niobrara age, and mechanical sediments appeared once more in the Cretaceous sea and settled down upon the surface of the chalk to become the lower beds of the Fort Pierre shales. The Fort Pierre shales are found as far east as Yankton, South Dakota, and recently Keyes claims that they have been identified in northwestern Iowa.* In the latitude of Sioux City they may have originally extended beyond the Sioux river. Our region during Cretaceous times witnessed, therefore, a fourth phase of sedimentation. With the incursion of mud that inaugurated the work of building the strata of the Pierre group, the condi-

*Proceedings Iowa Acad. Sci., Vol. Part IV, p. 25, 1894.

tions that made the Niobrara chalk possible were brought to an end. The swarming life that furnished the organic skeletons of which the chalk is constructed was unable to maintain existence under the changed environment.

It will be noted that in the Sioux river region the conditions that gave us successively the Dakota, Benton, Niobrara and Pierre deposits passed one into the other by practically imperceptible gradations. While in the Black Hills the transition from the Dakota sands to the Benton shales is very abrupt, along the Sioux river the transition is so gradual that any line of separation would seem to be purely arbitrary. Indeed it might seem as if any lines dividing a system of strata that have resulted from a process of continuous deposition under very gradually changing conditions must be more or less arbitrary. In the Sioux river region the Niobrara beds, however, stand out distinctly and sharply defined from all the rest both lithologically and micropaleontologically, and if divisions are recognized, these must rank as a separate formation. The features that distinguish this group of strata from the Dakota-Benton below and the Pierre above depend upon the fact that when the subsidence that affected the bottom of the Cretaceous sea and the adjacent shores was at, or below, a certain stage, mechanical sediments failed, and the absence of such sediments favored the enormous expansion of certain types of microscopic life endowed with power to protect their soft protoplasmic bodies with shells of carbonate of lime. The dead skeletons of successive generations of such organisms, unmixed with the grosser products of land erosion, constitute practically the only sediments that accumulated during the Niobrara phase of the Cretaceous. It is upon the nature of these skeletons and their mode of aggregation that the very unusual characteristics of the rocks belonging to this particular stage depend.

CHARACTERS OF THE DEPOSITS IN DIFFERENT LOCALITIES COMPARED.

As has already been said, the Niobrara deposits are not uniformly chalky; neither have they had everywhere exactly the same origin. They differ in these respects at different localities, and, to some extent, at different levels in the same exposure. Along the Sioux river certain portions of the for-

mation consist of thin-bedded, brittle, shelly limestones with chalky partings between the laminæ. In such cases the crowded valves of *Inoceramus problematicus* leave no doubt as to the principal source of the material composing the strata. Near Ponca, Nebraska, the Inoceramus-bearing beds are more compact than on the Sioux, and they are associated with heavier and more typical beds of chalk. A little farther up the Missouri, at Saint Helena, there are no Inoceramus beds. Traces of occasional valves may be found here and there in the uniformly massive layers that rise one above the other in a vertical wall of almost snowy whiteness; but there is nothing corresponding to the immense aggregations of individuals that we find farther east. There are some small colonies of *Ostrea congesta*, but, on the whole, mollusk shells make up a very insignificant part of the deposit. The thickness of the chalk at this point is about 90 feet, and it rests on a foundation of Benton shales that rise to a hight of 40 feet above the level of the water in the river. From Saint Helena to the mouth of the Niobrara the exposures of chalk on both sides of the Missouri present about the same general appearance. At Yankton, South Dakota, the chalk is used on a large scale in the manufacture of Portland cement. The beds worked for this purpose, embracing a thickness of about 60 feet, lie geologically above those seen at Saint Helena, but there are no essential differences in macroscopic characters to be noticed.

Paleontology of the Chalk.

It is aside from the purpose of this paper to discuss the general paleontology of the chalk, in the region we are describing, with any approach to fullness. A few general statements, indicating in a broad way the biological relations of the deposit, are all that can be undertaken. Vertebrate remains are not common, and the few that are known belong to fishes. The sharks were represented by the genera Ptychodus, Otodus, and Lamna, and of each there are indications of but a single species. Bony fishes were present, but by no means numerous. Among invertebrates the only forms at all conspicuous are *Inoceramus problematicus* and *Ostrea congesta*. The former flourished best in the eastern half of our area, the Ostrea is most common west of Ponca. But while forms large

enough for macroscopic study were comparatively few in number both as to individuals and species, microscopic life of wonderful beauty and of the highest scientific significance was developed in incomprehensible profusion. The characteristic faunas and the floras of the Niobrara must be studied with the microscope.

Hesitancy of American geologists to recognize the Niobrara deposits as Chalk.

Before discussing the microscopic life of the Niobrara age, it may be worth the while to notice an interesting mental attitude of leading American geologists to the question of the existence of chalk on this side of the Atlantic. Notwithstanding the fact that the earliest travellers up the Missouri river, and every one who has since followed in their footsteps, must have been convinced that the beds in question present, outwardly at least, all the physical characteristics of chalk, and notwithstanding the further fact that professor Bailey pointed out the foraminiferal origin of the material as long ago as 1841, there yet grew up a very firmly rooted notion that the peculiar earthy material we call chalk is not found in any of the geological formations of this continent. For example, professor Dana, in the second edition of his Manual, speaks of the beds of sand, marl, and loosely aggregated shell limestone in the Cretaceous strata of America, but he adds with intentional emphasis that "they include in North America *no chalk*." In the third edition of the Manual the statement is modified so as to read that "they include in North America no chalk, excepting in western Kansas, where, 350 miles west of Kansas City, a large bed exists." In the second edition of Le Conte's *Elements of Geology* we are told that chalk occurs "nowhere except in Europe;" but in the third edition it is stated that "recently good chalk composed of foraminiferal shells, and containing flints, has been found in Texas." In the *Geological Studies* of Dr. Alexander Winchell, the author, after discussing chalk, tells us on page 64, that "it does not occur in America;" and the impression is thought to be worthy of repetition in nearly the same words on page 433. In the *Canadian Naturalist* for 1874 Dr. G. M. Dawson has an arti-

cle on the Cretaceous rocks of Manitoba,* in which, referring to the Cretaceous of America in general, he says that "this formation contains no beds of true chalk." At the meeting of the Association of American Geologists in April, 1841, Nicollet gave an account of the geology of the regions covered by his explorations along the Upper Mississippi and Missouri. In this account the Cretaceous strata along the Missouri are noticed, and the statement is made that no true chalk or flint was observed. Lyell also encourages the notion that there is no chalk in America; but it will not be necessary to make further quotations in illustration of the attitude referred to.

While some of the leaders of geological thought on this side of the water have been slow to acknowledge the presence of chalk in the American Cretaceous, the plain people who are not geologists, not governed by conventionalities nor influenced by authorities, have never hesitated to call the material composing certain parts of the Niobrara deposits "chalk." At Saint Helena, Yankton, and wherever, indeed, the formation outcrops in massive layers, the material is constantly referred to as "chalk," "chalk-rock," or "chalk-stone." The use of one or another of these terms in common speech is more than fifty years old, for in 1841 professor Bailey received from the far northwest a sample of what was locally known as "prairie chalk."†

What is Chalk?

Whether the material composing the Niobrara deposits is chalk or not may depend somewhat on our definition of the term; but if in England the name is applicable to a soft whitish calcareous rock that accumulated on a sea bottom lying beyond the reach of mechanical sediments, and was composed of multitudes of practically entire shells of Foraminifera imbedded in an imperfectly indurated matrix of coccoliths and comminuted foraminiferal débris, then the term may be justly applied to a very large portion of the deposits of the Niobrara age along the Missouri river. For, in the first place, a very casual examination of the material would

*Note on the occurrence of Foraminifera, Coccoliths, etc., in the Cretaceous Rocks of Manitoba. *Canadian Naturalist*, vol. VII, No. 5, 1874.

†Amer. Jour. Sci. and Arts, first series, vol. XLI, p. 400, 1841.

establish its physical identity with much of the English chalk. In the second place, one needs only the cheapest of compound microscopes to demonstrate that it is surprisingly rich in the most perfectly preserved specimens of Foraminifera that in a large number of cases are specifically the same as those so long known in the chalk of Europe. In the third place, a better microscope will show that every cubic inch of the Niobrara chalk contains many millions of the minute circular or elliptical, disk-like bodies called coccoliths, which cannot be distinguished from similar bodies occurring in similar numbers and in similar relations in typical chalk on the other side of the Atlantic.

Some References to Literature in which either the Chalky Character or Foraminiferal Origin of the Niobrara Deposits is Recognized.

In view of the widely prevalent impression that the American Cretaceous contains no chalk, some references to the literature in which the chalky character or foraminiferal origin of the beds in question is recognized may not be without interest. In the American Journal for 1841* Prof. J. W. Bailey describes the sample of "prairie chalk" already noted as being very rich in beautiful forms of the "elegantly little." The "elegantly little" are Polythalamia (Foraminifera) and of these he gives four excellent figures which, although unnamed, are readily recognized as common species composing a large proportion of typical chalk, whether we collect it in England or along the Missouri river. In the same note it is stated that professor Bailey has also found very interesting forms of Polythalamia in the specimens collected by Mr. J. N. Nicollet from the "far west."

In 1843 Ehrenberg published his *Memoir on the Extent and Influence of Microscopic Life in South and North America.* Most of the work is devoted to diatoms and desmids, but a few pages are given to the discussion of Foraminifera, including forms from the Cretaceous chalks and marls along the Missouri river. The abundance of foraminiferal species and the identity of some with species occurring in the chalk of Europe are among the facts established.

*Loc. cit.

An extended notice of Ehrenberg's memoir by professor Bailey was published in 1844.* Copious extracts from the memoir are incorporated in the notice, and in a foot-note there is a figure of what is supposed to be *Textularia americana*. A year later there is another paper by professor Bailey, which appears in the 48th volume of the same Journal, and in the course of which the author says, concerning Foraminifera in specimens from the Missouri river, that "they are remarkably abundant and beautifully preserved."†

Between 1853 and 1861 Meek and Hayden worked out the succession of Cretaceous strata along the Missouri. Numerous papers were published under the joint authorship of the geologists named. The chalk of the Niobrara is frequently mentioned, sometimes as "chalk marl," and sometimes as "calcareous marl weathering to a yellowish or whitish appearance above;" and in their detailed section, published in the Proceedings of the Academy of Natural Sciences, Philadelphia, December, 1861, the "calcareous marl" of Formation number 3 is said to contain "several species of Textularia."

The beds to which professor Dana refers in his Manual as the only known example of American chalk are doubtless the ones described by Mr. D. C. Collier in 1866.‡ Of the material forming these beds, which extend for a distance of over one hundred and fifty miles east and west, Mr. Collier says: "On one occasion, in company with a companion, I was able to climb to the top of a bluff of pure chalk, so soft that I could cut and carve it with the knife I carried in my belt, and so fine that it covered my clothes as thoroughly as when in my college days a classmate wiped the blackboard with my back."

In his first Annual Report of the United States Geological Survey of the Territories, Dr. Hayden takes occasion to say concerning the Niobrara division of the Cretaceous: "Its principal character is a gray or light yellow chalky limestone; much of it so pure as to make a good chalk for commercial purposes."§

*Am. Jour. Sci. and Arts, first series, Vol. XLVI, p. 297, 1844.

†Ibid., Vol. XLVIII, p. 341, 1845.

‡Am. Jour. Sci., second series, Vol. XLI, May, 1866.

§First Ann. Rep. of the U. S. Geol. Survey of the Territories, embracing Nebraska, by F. V. Hayden, U. S. Geologist, p. 54, 1867.

In 1870 Dr. Charles A. White, in discussing the Inoceramus beds along the Sioux river, which are in Iowa the equivalent of the Niobrara of Meek and Hayden, tells us that, among other fossils, "minute Foraminifera (probably Globulina) are sometimes met with in great numbers."*

The article by Dr. G. M. Dawson, already cited as appearing in the *Canadian Naturalist* for 1874, marks a very important step in advance of all previous publications in the matter of investigating the origin and composition of the Niobrara chalk. The strata of Manitoba that were the subject of investigation are the northward continuation of the chalk beds of our Sioux river region, and Dr. Dawson was able to compare microscopically the Manitoban with Nebraskan material. The article is illustrated with figures of Foraminifera, and speaking of this group of organisms he says: "The general facies of the foraminiferal fauna of the Cretaceous rocks of Manitoba and Nebraska singularly resembles that of the ordinary English chalk. Both abound in Textularine and Rotaline forms of similar types."

Dr. Dawson's paper, however, owes its chief importance to the fact that it is the first, so far as I know, that recognizes coccoliths as agents in the formation of American chalk. Coccoliths, in my judgment, are much more characteristic of chalk than Foraminifera. Individually they are thousands of times more numerous, and collectively they make up a much larger proportion of the bulk of true chalk than do the larger and more obtrusive foraminiferal shells. Chalk composed of Foraminifera, either broken or entire, is harsh and rough and unsuited to many purposes to which this substance is applied. Coccoliths on the other hand rarely exceed the one-hundredth of a millimeter in diameter, and chalk formed out of such minute bodies is soft, works smoothly on blackboard or chalk line, and may be ground between the fingers to an impalpable powder. Dawson's paper is illustrated with a number of figures showing the characteristic appearance of coccoliths under a high amplification, and along with the coccoliths there are illustrations of a number of the minute calcareous rod-like objects to which the name rhabdoliths has been applied. Relatively speaking, rhabdoliths are not common in

*Geology of Iowa. Dr. C. A. White, Vol. I, p. 294, 1870.

the beds we are considering. They have contributed only a small percentage of the bulk of the material making up the deposit. It must be said, however, that the paper under consideration has the further distinction of being the first to announce the presence of these interesting and curious structures in the fossil condition.

In Texas, professor Hill recognizes two chalk horizons, one in the Lower Cretaceous, the other in the upper series of the same system. We are only concerned here with the chalk of the Upper Cretaceous, for that alone corresponds in age to our Sioux river beds. That this formation abounds in Foraminifera such as Textularia and Globigerina, and that it is in reality chalk, professor Hill urges with pertinent force in a number of publications;* and it is to the writings of Hill that professor Le Conte refers when he acknowledges the presence of true chalk in Texas.

Hill's work on the geology of Arkansas† is the subject of an admirable review by professor Marcou,‡ in the course of which Marcou calls attention to his discovery of *true chalk* near Sioux City (Iowa) and in Nebraska in 1863. Speaking of his paper on the Cretaceous formations in the vicinity of Sioux City, etc., read before the Geological Society of France in 1866, Marcou says: "I took the precaution to carry with me pieces of rough chalk taken near Sioux City, and I drew on the blackboard with them the three sections that accompany the paper."

Prof. S. W. Williston, in 1890, announced that the chalk of Kansas "appears to be wholly composed of organic forms very readily visible under a comparatively low power (a one-fifth or a one-sixth objective and a C eye-piece)§." The forms seen by professor Williston are the minute coccoliths and rhabdoliths which Dr. Dawson so well described in 1874, and

*Ann. Rep., Geol. Survey of Arkansas, Vol. II, for 1888. Check List of Invertebrate Fossils from Cretaceous Formations of Texas, 1889. Annotated Check List, etc., Bulletin No. 4, Geol. Survey of Texas, 1889. Foraminiferal Origin of certain Cretaceous Limestones, etc., AM. GEOLOGIST, Sept., 1889. Geology of parts of Texas, etc., Bulletin, Geol. Soc. Am., March, 1894.

†Report cited.

‡AMERICAN GEOLOGIST, vol. IV, p. 357, Dec., 1889.

§Chalk from the Niobrara Cretaceous of Kansas, Science, Vol. XVI, p 249, Oct., 1890.

at the time of writing the note under consideration the comparatively large Foraminifera, which may be seen with a good pocket magnifier, seem to have been overlooked. A few months later, however, Williston renewed his observations on the chalk of Kansas, and his report of these later investigations contains the statement that "the deposit seems wholly formed of coccoliths, rhabdoliths and Foraminifera, with, perhaps, radiolarians and sponges."*

The foregoing references selected from the mass of literature appearing between September, 1841, and March, 1894. while incomplete as a bibliography relating to the physical characteristics and foraminiferal origin of American chalk, may yet help to make clear the successive steps whereby geologists have been led from complete skepticism regarding the presence of chalk on this side of the Atlantic to the conviction that considerable portions of the Niobrara beds along the Sioux and Missouri are, in all the particulars relating to composition and origin, identical with the chalk of Europe.

Composition of the Niobrara Chalk in the Sioux River Region.

The characteristics of the Niobrara chalk are such that exhaustive investigations with the microscope may be carried out with very little difficulty. In thin sections from selected typical beds the unbroken shells of Foraminifera are very conspicuous. They lie in close proximity to each other, and their inflated chambers, filled with crystals of calcite, sometimes occupy more than one-third the area of the entire field. It is certain that more than one-fourth and in some instances probably one-third of the volume of the chalk is composed of foraminiferal shells still practically entire. The matrix in which the shells are imbedded is made up of a variety of objects, the most numerous, and the most conspicuous under proper amplification, being the circular or elliptical calcareous disks known as coccoliths. The small rod-like bodies to which the name rhabdoliths has been applied are not very common, although their presence is easily detected with a moderately high power objective.

Mingled with the coccoliths and rhabdoliths are numerous fragments that are evidently the débris resulting from the

*Proc. Kansas Acad. Sci., Vol. XII, p. 100. 1891.

comminution of foraminiferal shells; while standing out conspicuously amid the remains of these minuter organisms are comparatively large calcareous spicule-like bodies, which, on investigation, turn out to be the disassociated rods that made up the external prismatic layer of shells of Inoceramus. This outer layer in *Inoceramus problematicus* seems invariably to have become detached from the inner nacreous layer, and, almost without exception, it has become completely disintegrated into its constituent prisms. And so it happens that, in the Inoceramus-bearing beds of the deposit, the soft matrix in which the only remaining portions of the shells, the nacreous portions, lie imbedded, is composed very largely of these rod-like prisms mingled with skeletal parts of the ordinary chalk-forming organisms. Even in the typical, massive, chalky beds that bear no outward traces of mollusk shells of any kind, these same prisms, while greatly diminished in numbers, are by no means uncommon; and so in any consideration of the constituent elements of the chalk these separated units from the external layer of valves of Inoceramus must be reckoned as no unimportant factor.

When the chalk is treated with acid there remains a small amount of insoluble matter consisting of clay, fine grains of sand, a very few minute pebbles, none of which, so far as observed, exceed five millimeters in diameter, and a small number of internal casts of the chambers of Foraminifera. Nearly all the foraminiferal shells have the chambers filled with calcite; a few have these cavities still empty or filled simply with air; but in a small number of cases the chambers were filled with an opaque, insoluble mineral, probably silica deeply stained with iron oxide, that remains as perfect internal casts after the shell has been dissolved in acid. The amount and composition of the residuum varies with the purity of the chalk. In the purer samples it scarcely exceeds one per cent., in others, of course, the percentage ranges very much higher.

THE MICRO-PALEONTOLOGY OF THE CHALK.

In all the chalk examined the Foraminifera are very numerous. Many are large, vigorous looking specimens of the types to which they belong, and an unusual number of the shells remain perfect. They are easily separated from the finer particles constituting the matrix by carefully grinding the chalk

under water in a shallow dish, decanting and renewing the water as long as gentle rubbing of the heavier residual material produces any traces of milkiness. The particular genera and species that will be found after the washing process is complete will depend somewhat on the locality from which the specimen under investigation was derived. Even at the same locality samples of chalk from different beds will be found to differ in a marked degree so far as relates to the presence or absence, the association, or the predominance, of certain types. It would be very tedious, unprofitable and altogether aside from my purpose, to give you a catalogue of the genera and species of the foraminiferal fauna. Indeed, according to Carpenter, Brady, and other authorities, species in the sense of constantly differentiated races do not exist among Foraminifera, and it is almost impossible to define genera; but some general statements, which may lead to scientific considerations of some importance, may be possible and permissible under the circumstances.

THE FORAMINIFERA, WITH OBSERVATIONS ON THEIR DISTRIBUTION.

Saint Helena, Nebraska, seems to me to be the most typical locality in the region under consideration. In samples of chalk from this locality large forms of *Textularia globulosa* of Ehrenberg are the most common and the most characteristic fossils. Here the species presents its ideal characteristics. The chambers are inflated and spherical, and the shell is robust and widens rapidly toward the larger end. This same shell, be it remembered, ranges throughout the Niobrara of America from Texas to Manitoba, and it is one of the most conspicuous forms at certain horizons in the chalk of Europe. Associated with *Textularia globulosa* is a smaller shell that is proportionately thinner and narrower and every way less robust. In some places this smaller form is the prevailing type. It has been regarded as a distinct species, and was figured by Dawson, in the paper already cited, under the name of *Textularia pygmæa*. While these two forms grade into each other perfectly when a sufficient number of specimens is examined, it will be profitable for the present to keep them apart, inasmuch as the distribution of the two types presents some facts worthy of consideration. Recall for a moment the geographical and bathymetrical conditions of the region while the chalk

was forming. The shore line of the Niobrara sea extended northeasterly from near the southwest corner of Iowa. From that shore line the sea spread away westward to beyond the Rocky mountains. The site of Saint Helena was many miles from shore, and was covered by moderately deep, clear water. unpolluted by detritus washed in from the land. It was in this pure, clear sea that *Textularia globulosa* found the conditions most favorable to its existence. Here it multiplied beyond all calculation, here the individuals show all the symptoms of normal health and vigor, and here they attain their ideal symmetrical form. As, however, we approach the shore, it becomes evident that the conditions, so far as Textularia is concerned,became more and more adverse, for the chalk from Sioux City, Hawarden, Auburn, and other points east of the Sioux river, contains but few of the vigorous forms we have noted. On an average the textularians do not attain more than half the size reached by the larger individuals from Saint Helena. At Auburn, the most easterly point at which the chalk is known to occur in place, only the smallest forms of *Textularia pygmæa* occur. In this connection there is another very striking fact worthy of notice. The textularians from the more easterly localities are often very unsymmetrical and irregular in their mode of growth. It would seem that they were not only starved and stunted, but they were frequently deformed by the unfavorable environment prevailing in regions approximate to the shore.

In some of the beds at Sioux City, which is one of the intermediate points between Auburn and Saint Helena, the diminutive forms of Textularia are very numerous, but mingled with them are a few conspicuously large individuals recalling those from the great chalk cliffs farther up the Missouri. There is one very marked difference, however, between these and the specimens from Saint Helena. Like the smaller individuals of the same region they are more or less distorted. What is more, the later formed chambers of the larger specimens often depart from the biserial type. and the shell may terminate in various irregular ways. There may be at last but a single series of cells, but it is more common to find three, four, or even five series. Sometimes groups of extra chambers protrude from the sides of the shell like unhealthy

excrescences, and again the later chambers may be simply heaped together in inextricable disorder. Everything suggests abnormal, if not positively diseased, conditions. The depauperating effects of unfavorable environment seem to have acted in three ways: first, to retard growth and thus produce the pygmæan type; second, to cause deformity by unsymmetrical growth even when the biserial arrrangement is maintained; third, to interfere with the biserial arrangement of the later formed chambers among the more vigorous individuals, and to produce all possible types of departure from normal regularity.

In all the thousands of specimens examined I have seen nothing corresponding to Bailey's figure of *Textularia americana*, nor have I been able to recognize as many species as Ehrenberg described from the region along the Missouri. There are endless variations, many of which would doubtless have been formerly regarded as of specific value; but, after all, I can see no reason for regarding all the textularians of the region, with their countless variations as to size and proportions, including departures from symmetry and biseriality, as other than varieties of a single species which for the present we may call *Textularia globulosa* Ehrenberg.

While Textularia seems to have flourished best in the deeper and purer waters remote from shore, the reverse is true of another group of forms that have usually been identified with Ehrenberg's *Rotalia globulosa* or *Rotalia aspera*. According to Brady, these may all be referred to the genus Globigerina and represent a single species, the *Globigerina cretacea* of d'Orbigny. The forms in question present a wide range of variation among themselves, but the average or ideal consist of one or two spirally arranged whorls of rapidly increasing globular chambers the walls of which are thin and perforated by relatively large foramina. Among the departures from the average type there are some with few, large chambers, agreeing well with *G. bulloides*; while in slides from Saint Helena there are occasional individuals in which the last chambers are curiously elongated so as to impart to the entire shell an aspect identical with Brady's species, *Globigerina digitata*. The earlier formed chambers are in all respects like those of the typical *Globigerina cretacea*, and it

will be in perfect accord with biological conceptions to regard the peculiarities of the individuals in question as due to accidental variations in the form of the terminal chambers, and not as permanent characters indicating a distinct species. The young of the Globigerinæ float at the surface, but as the shells, with age, increase in size and thickness the animals sink through the water and their minute tests become mingled with those of other species that spend their entire life in the ooze at the bottom. Now Brady's specimens of *Globigerina digitata* came from bottom dredgings. The species was never taken with the tow-net at the surface. It is probable that in each case the abnormal chambers were added after the organism came to final rest amid the bottom ooze; and it is at least possible that the abnormality noticed may be due to the fact that amid this ooze the restrictions to normal growth are very much greater than those affecting the animals when floating freely near the surface. We have seen in the deformed and otherwise abnormal textularians that the simple protoplasm making up the bodies of Foraminifera responds to changes of environment in such a way as profoundly to affect the form and proportions of the shell; and it is quite possible that, in the crowded conditions existing upon the sea bottom, some individuals were so unfavorably situated as seriously to interfere with normal, symmetrical growth. It is an interesting fact that the deformed specimens of Globigerina are associated with the vigorous symmetrical types of Textularia at Saint Helena. Nearer the shore, as indicated by the material laid down at Sioux City, Hawarden, Auburn, and other points east of the Iowa boundary, the Globigerinæ flourished in greater profusion than farther west, and evidence of distortion, or any interference with normal growth, among the multitudes of vigorous looking individuals that crowd the strata in this marginal part of the Niobrara basin, are extremely rare.

While Textularia and Globigerina are the predominent types in the region under consideration, there are other genera that show similar peculiarities of distribution. For example, a very beautiful species of Truncatulina, or probably Anomalina, is somewhat common at certain levels in the exposures at Saint Helena and Yankton, but there is not even a trace of

it in the deposits east of the Sioux river. Specimens of Bulimina are not rare, and Polystomella, Cristellaria, and Frondicularia, occur occasionally at the western localities named, but farther east they are so far unknown. On the other hand, there are some genera peculiar to the region east of the Sioux, but it would scarcely add anything to the force of the facts already stated to enumerate them.

PROBABLE CAUSE OF THE DIFFERENCES OBSERVED.

Is it possible to assign any cause for the observed differences in the foraminiferal faunas of the eastern and western portions of the Sioux river region? Remember that from the beginning of the Dakota age to near the close of the Niobrara the region was practically one of progressive subsidence. There are evidences that we cannot now discuss of numerous oscillations of level, but on the whole the tendency of the sea bottom and the adjacent lands was downward. During the culmination of the peculiar conditions characterizing the Niobrara, the sea was clear and had considerable depth, but not abysmal, over the present sites of Yankton and Saint Helena; while farther east the waters were shallower and may sometimes have been polluted by rock detritus to a slight extent during the upward phases of oscillation, or during periods of excessive rainfall. All the evidence suggests a clear peaceful sea with its bottom gradually sloping away from the shore to only moderate depths. Upon the bottom of this sea the textularians flourished, while floating near the surface were the younger individuals of the globigerine forms already noticed. Either floating in the water or resting upon the bottom were the peculiar coralline plants of which the bodies called respectively coccoliths and rhabdoliths were constituent parts.

Now, the differences noted between the textularians at Saint Helena and those at Sioux City and Auburn are in some way connected with differences in physical conditions at the points mentioned. The only differences that are readily suggested are the differences in the depth and in the amount of earthy sediments over different portions of the area.

No one can tell how such slight differences of environment would react on the simple living matter of Textularia, but that they did affect it profoundly becomes obvious upon

comparing the shells of the beautiful, symmetrical thrifty-looking specimens from Saint Helena with those of the starved, impoverished, deformed specimens from Sioux City and Auburn. In the case of the globigerine forms that during most of their lives float near the surface, the condition of the bottom was not a matter of so much moment. The water at the surface was doubtless clear enough for their purpose, for even the small amount of sediment discharged into the sea by the sluggish, nearly base-leveled streams must have been limited to the lower strata of the water. Near the surface, too, food was doubtless even more abundant than it was at the same depth farther west, and thus it happened that near the shore the Globigerinæ flourished, and their full grown shells, bearing every indication of life under most favorable conditions, settled down among the unhealthy and depauperated textularians to which life had been a perpetual struggle with adverse surroundings. The shallow-water chalk contains large numbers of shells of vigorous Globigerinæ mingled with many small and deformed shells of Textulariæ, while the deep-water chalk abounds in robust textularians with relatively few Globigerinæ. Among the globigerine shells of the deeper water are a few rather remarkable monstrosities.

Comparison with English Chalk.

An attempt was made to compare our American chalk with that of England, but the opportunities for getting the desired number of examples from abroad were not good and the results are not altogether satisfactory. Enough, however, was determined to demonstrate the presence in English chalk of the same species of Textularia and Globigerina that are so common along the Missouri; there are closely allied species of Frondicularia, Bulimina, and Truncatulina; there are also prisms from the outer layer of Inoceramus shells; while enclosing and imperfectly cementing together all the larger objects are minute, dust-like coccoliths that cannot be distinguished from those making up so large a percentage of the deposits of the Niobrara. The conclusions so long ago reached by Ehrenberg and Bailey* as to the identity of European and Missouri river chalk seem to be fully established. The water

*Reports of the First, Second and Third Meetings of the Association of American Geologists and Naturalists, p. 357, 1843.

in which the English chalk was deposited was probably deeper than the Niobrara sea between the present site of Yankton and the eastern shore, somewhere near the middle of Iowa. Neither sea was necessarily very deep. As to our Sioux river area of deposition I conceive that the lands draining into it had subsided practically to base level, and that therefore chalk may have been deposited within a few miles of shore. The singular absence of corals, sea-urchins, and all the higher forms of marine invertebrate life, except one species of Inoceramus and one of Ostrea, requires explanation, but at present there is none to offer. The seas of the English chalk were somewhat richer in respect to such types of life than ours; but, compared with many other seas, their striking poverty in all but lowly organized microscopic forms must be acknowledged.

The practical identity of conditions in the two widely separated regions we have been comparing remains a fact of much scientific interest. While, in the forms of coccospheres and Foraminifera, the lowly and the obscure of earth's organic hosts were revelling in peaceful and unpolluted seas in the longitude of the first meridian and contributing their dead skeletons to form the chalk of Europe, far away to the west, beyond the 90th meridian, more than a quarter of the way around the globe and separated from the first area by an abysmal ocean and a continental mass of land, there was another clear sea with low flat shores in which the same or very similar humble types of life were contributing material to form the chalk beds of Iowa, South Dakota and Nebraska.

SUMMARY OF FACTS PROVING THE CAMBRIAN AGE OF THE WHITE LIMESTONES OF SUSSEX COUNTY, NEW JERSEY.

By Frank L. Nason, New Brunswick, N. J.

In the prolongation of the Appalachian system through northern New Jersey, eastern New York and beyond, there exist areas, some portions of which are white, highly crystalline limestones, while others are blue and more or less unaltered; the former have generally been assumed to be of

Archæan age. The basis of this assumption as to the age of these rocks is evidently due to their association with the gneisses and highly metamorphosed rock which form so prominent a feature of this region, together with their highly crystalline condition, and to the general absence of fossils. Upon such evidence, their Archæan age has not only been generally accepted, but considered so positive a fact by many authors that such features as they present have been used as a factor in determining the supposed Archæan age of limestones elsewhere, and, in general, as proof positive of presedimentary limestones.

This determination of these and other crystalline areas was quite natural and consistent at the time it was first made in New York and New Jersey: for then the whole sedimentary series was terminated below by the Potsdam sandstone, and everything older was considered as belonging to the Azoic. With the progress of geological science, and after the establishment of the Cambrian or Taconic system of rocks, one by one these pre-Potsdam sedimentaries have been rescued from the Azoic or Archæan and their Cambrian age established by means of fossils. In general there remain undetermined at the present time only the more crystalline and metamorphic regions generally not directly connected with unaltered sediments of known age. In many cases the crystalline areas shade off into fossiliferous strata in undisturbed regions and their correlations have been determined.

It thus appears that many areas of altered sedimentary rocks, such as crystalline limestones, schists and quartzites still remain in the Archæan, simply because they cannot yet be correlated with any known horizon. This is in itself no evidence of their true relationships, and is inconsistent with proper methods of geological correlation. It is a curious fact that the assumption having once been made that these rocks were of Archæan age, the lithological features that they displayed, especially in the presence of chondrodite, gradually came to be regarded as proof in itself of their Archæan age.

These crystalline limestones have, since 1864, been described in the various reports of the Geological survey of New Jersey as members of the series of crystalline rocks of Azoic or Archæan age. In 1888 and 1889 the writer was engaged

in studying the limestone area in northern New Jersey, and the facts observed in the field led to serious doubts as to the correctness of the views previously held. This led to a detailed investigation of the area, especially in the vicinity of Franklin Furnace, which resulted in accumulating a series of related facts which prove conclusively the post-Archæan age of all of the limestones and quartzites in this region. These results were published by the writer in 1890,* but owing to the great length of time during which the former view had generally been held, and during which it had come to be considered as a positive fact, these conclusions met with a tardy acceptance and are still doubted by some. Additional papers on this subject have been published by the writer;† and recently Kemp and Hollick, in an excellent paper‡ on the northern portion of the same area extending into New York state, reach the same conclusions as a result of their very careful work in the field and in the laboratory. It therefore seems to be an appropriate time for a concise summary of the facts which prove that the white limestones of Sussex county, N. J., including the deposits of franklinite and zinc ores, are of Cambrian age. This it is proposed to do by establishing the truth of the following statements:

1. The white limestones are continuous with the blue limestones (now accepted as of Cambrian age) and every degree of transition may be found between them.
2. Both have the same dip and strike.
3. Both are conformable with a quartzite also containing Cambrian fossils.
4. Both are unconformable with the gneiss upon which they rest.
5. Both have in sum total the same chemical composition and are magnesian.
6. The altered crystalline condition of the white limestone is due to the intrusion of igneous masses and to regional metamorphism, while the blue limestone never contains such igneous injections.
7. The presence of certain minerals, especially chondrodite, is not indicative of geological age.

1. *The continuity.* In crossing the strike of the limestones from the white to the blue, where there is a continuous exposure, one of two things is always to be observed: either (*a*)

*Ann. Rep. State Geol. of N. J., 1890.

†AMERICAN GEOLOGIST, April, 1891; Sept., 1891; March, 1894. Trans. Am. Inst. Min. En., Feb., 1894.

‡Ann. N. Y. Acad. Sci., vol. VII, 1893.

there is a continuous but gradual transition in color and crystalline texture; or (*b*) there is a brecciated zone.

(*a*) In many localities where the white and blue limestones lie in close proximity, it is to be observed that the former has lost its most striking characteristics. It is no longer coarsely crystalline; its color is neither white nor yellowish white, but has rather a bluish tinge. The graphite, which, in the coarser rock, occurs in bright crystalline scales, appears rather as a dull earthy mineral, with occasional bright flecks. The rock has usually a pressed appearance, and in many instances a distinct slaty cleavage. At this stage the graphite, perhaps, would even yet suggest that the limestone should be classed with the crystalline series; but within a few feet these characters change, the rock becomes less and less crystalline, the graphite loses the last trace of crystallization and shows as cloudy carbonaceous aggregations, and then comes the wholly unchanged blue dolomite. This transition is to be seen in a score or more of localities; but to make sure that there was no possibility of error, the writer had a trench dug across the strike of the rocks showing a *continuous* exposure. The only result of this trench was to disclose more detail which served to verify the conclusions reached in other localities.

(*b*) In another phase of the observed transition, as has already been stated, the rocks are brecciated at the point where contact should be observed if they belonged to different horizons. Instead of the pressed appearance, with consequent development of slaty cleavage, one passes quite suddenly from the coarse white limestone to a zone of breccia. This is made up in places of practically unchanged, angular blue limestone fragments, with interstitial filling of coarsely crystalline, white, graphitic limestone. Breccias also occur in the midst of large white limestone belts; and distinct fragments of limestone are frequently found which are less white, less crystalline and less graphitic than the enclosing mass. If the white graphitic limestone is older than the blue, how can it contain fragments of it?

2. *Dip and strike.* There are many places which show exposures of both the blue and white limestones. Their dip is the same, and also their strike. Instances may be found without number, and the details of many of them are given in

the publications cited. Along anticlinal axes one side may be wholly white limestone, while the other may be part blue and part white, both the latter having the same dip and strike, as is shown in one instance in the Rudeville quarries, and similar facts have been observed elsewhere.

3. *Conformability with quartzite.* The blue limestone has been shown (loc. cit.) to contain *Obolella crassa*, and is therefore referred to the Lower Cambrian. The quartzite, which generally underlies the limestones of the region, contains abundant remains of *Olenellus* and other fossils, and its age is thus positively determined to be Lower Cambrian.

Wherever studied, both the white and blue limestones are found to be conformable with and above this fossiliferous quartzite or sandstone; *and therefore they cannot be of Archæan age.* A good illustration of this may be seen in Hardistonville, where the graphitic *fossiliferous* quartzite in contact with the granite is conformably overlaid with a coarsely crystalline graphitic limestone which gradually passes out into a fossiliferous blue limestone overlying the same quartzite. The white limestone is continuous with that of the region and is everywhere filled with intrusives.

These relations are diagrammatically represented in the adjoining figure. The sandstone being less affected by metamorphic action than the limestones, retains its fossiliferous contents up to the line of contact with the dike.

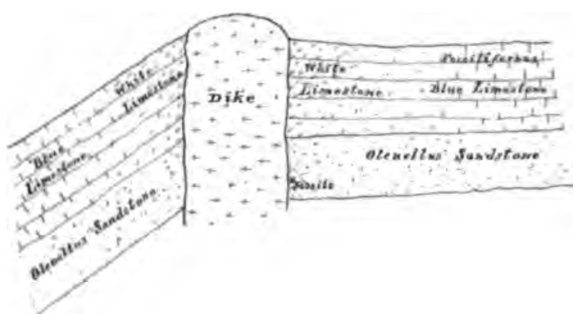


FIG. 1. Effects of a granite dike on Cambrian limestone and sandstone. Hardistonville, N. J.

4. *Unconformability with the gneiss.* In spite of the fact that there is apparent conformability with the franklinite and zinc beds of Franklin Furnace, the conformability is only ap-

parent and not real. The fossiliferous blue limestones and sandstones, dipping to the northwest lie on the upturned edges of the series a few hundred feet to the west. But following along the strike of both outcrops, the white and the blue, the two come together and completely cover the gneiss just north of the Trotter mine.

Instances have been mentioned in this paper where anticlinal axes, one flank being blue and the other white, at one end of a hill, have both flanks white at the opposite end. No gneissic anticlines have been observed in the valley, while anticlinal structure is very common in the white limestones and with white and blue, as mentioned.

The statement that gneisses occur interstratified with the white limestone is erroneous. There is no phenomenon of the kind to be observed. Granite, greenstones, and scapolite diorite are of frequent occurrence, but they are doubtless eruptives; the granites are certainly so.

5. *Identity in chemical composition.* It has always been considered that while the blue limestone is magnesian, and therefore a dolomite, the white is purely calcareous; and this has been used as an argument for considering them as distinct. As a matter of fact, however, as the writer has shown by an extended series of chemical analyses,* the white limestone is also dolomitic, and it was further shown that the percentage of magnesia varies from place to place in each, and that specimens of both can be obtained which have the same composition.

It is true, that in the immediate contact with igneous rocks, the carbonate that is present is essentially that of lime, and that the rock often shows a decreasing content of magnesian carbonate as the eruptive is approached: but this may be readily explained by a consideration of the following facts.

The white limestones are well charged with crystallized minerals: the blue limestone is free from them. The transition zones show mineralization in a decreasing degree fron the white to the blue. The chemical composition of the white and blue rocks does not vary essentially. Magnesia is not present in a fixed percentage in dolomitic limestone, and it is certainly not constant in the blue one of Sussex county. The

*AMERICAN GEOLOGIST, March, 1894.

range of magnesia is very great, but it is never absent from either variety as shown by the analyses. In considering the chemical composition of these rocks as a whole, the composition and distribution of the minerals contained in the white limestone must also be taken into account. These are confined to the vicinity of eruptive rocks, especially the granites and scapolite diorites; and it will be there found that the carbonate rock which contains them is now low in magnesia. It will also be observed that the principal minerals are those high in magnesia, such as phlogopite, biotite, pyroxene, hornblende and especially chondrodite, which is the most abundant of all and contains over 50 per cent. of it. Considering, then, the foregoing facts, it is impossible to escape the conclusions that the magnesia in the minerals has been derived wholly from the rock in which they are now found, and that the containing limestone was formerly a dolomite and has become de-dolomitized by the metamorphic action of the intruded granites and other eruptives. Were the magnesia now locked up in these minerals re-distributed in the form of a carbonate through the containing limestone, the result would be a dolomite in no way distinguishable from either the white or blue dolomite.

6. *Present condition of the white limestones due to igneous rocks.* The white limestones and the blue as well are not isolated, the one from the other, but they lie in the same valley, shifting from side to side with the appearance of granite or other intrusive rocks. Moreover, the white limestones are never found outside of a greatly disturbed belt, and never far distant from igneous masses. This point has been touched upon so many times that it is hardly necessary to repeat it, but the fact is so patent to a field observer that it cannot be emphasized too strongly. The crushing, heat, and pressure, resulting from this great complex of intrusions, were amply sufficient to completely metamorphose much more refractory sediments than these.

7. *Chondrodite not indicative of geological age.* The minerals associated with the white limestones have long been used as an argument in support of its Archæan age. So many of them, however, have been shown in various localities to be merely the result of metamorphic action of intruded igneous

masses, that this point has almost wholly lost the significance it once possessed. By some, however, the mineral chondrodite is still used in this way with the force and rank of a characteristic fossil, since it occurs abundantly in certain phases of the white limestone.

Prof. J. D. Dana* has well observed in a paper on certain rocks of the Connecticut valley: "What reason is there in chemistry or geology why crystals of andalusite and staurolite should have been made only in pre-Silurian time? Andalusite consists simply of alumina and silica, and staurolite of the same along with iron. These three ingredients are now and ever have been the most abundant of all the mineral constituents of the globe."

To these chondrodite might well be added, along with all other minerals, since their production depends upon a union of certain chemical elements under the proper physical conditions and is in no wise a function of geological age.

In regard to chondrodite, composed as it is of silica, alumina, magnesia, iron and fluorine, no one would claim that its elements were Archæan or restricted to Archæan formations, unless, possibly, it might be the fluorine. This latter element, however, along with boric acid, is well known to be one of the most constant accompaniments of igneous magmas, revealing itself in the composition of various minerals formed by fumarole action. Many instances of this might be given, but, as geological literature is full of such, it will be sufficient to cite the well known occurrence of topaz in the cavities of rhyolites in Colorado and Mexico; while the actual presence of hydrofluoric acid in gaseous emanations from the fumaroles in the crater of Vulcano has been shown by actual chemical tests by Scacchi,† and various volatile fluorides are known to occur after eruptions as efflorescences at Vesuvius.

Moreover, the fact that chondrodite is not always of Archæan age is proved by its well known occurrence at Mt. Vesuvius in cavities of the ejected blocks of the Cretaceous dolomite which forms the pediment of the volcano. Its formation there is evidently due to the action of mineralizing vapor.

*Am. Jour. Sci., III, vol. vi. p. 350, 1873.

†Att. Acc. Napoli, 6, 1873, Cont. Min. II, 1874.

under great heat and pressure, upon the limestone blocks, and it is, therefore, a marked instance of contact metamorphism.

Chondrodite is in fact a mineral resulting from the contact action of igneous magmas on magnesian rocks, and, far from being a function of their geological age, it is most certainly indicative of the close proximity of intruded igneous rocks.

In conclusion, from the establishment of the continuity of the white and the blue fossiliferous limestones in New Jersey; their conformability with the fossiliferous Cambrian quartzite; their unconformability with the underlying gneisses; their identity of chemical composition; their differentiation only through igneous action; and their similarity of dip and strike—the writer has proved their Cambrian age and that their reference to the Archæan is no longer tenable.

THE ELK HORN CREEK AREA OF ST. PETER SANDSTONE IN NORTHWESTERN ILLINOIS.

By Oscar H. Hershey, Freeport, Ill.

In the various reports of the Illinois Geological Survey we find mentioned and described only three areas of outcrop of the St. Peter sandstone in the state, namely, along Rock river from Grand de Tour to Oregon, along the Illinois river in La Salle county, and at the Cap au Gres bluff in Calhoun county. Nor have I been able to learn from any other published source of the surface exposure of this characteristic formation in any but the above tracts. So when, some months ago, I accidentally discovered a considerable outcrop of the sandstone in a valley in the extreme western part of Ogle county I made a somewhat detailed study of it, which study has resulted in bringing to light several perhaps not unimportant facts.

As indicated by the accompanying map, the outcrop under discussion occupies the valley of the Elk Horn creek and tributary streams, in Ogle county, about one to seven miles southwest of the village of Foreston. It reaches the Carroll county line at several points, at the most northern of which it extends into that county about half a mile.

The topography of the tract is essentially that of the drift-

less area, modified but slightly by glacial action. The ice seems to have passed over the country without abrading the rock surface, except on the crests of the highest hills. The amount of till or boulder clay deposited in the region is insignificant, but the chief obstacle to an examination of the stratified rocks is presented by a mantle of loess, which, though rarely exceeding 8 or 10 feet in thickness, is continu-

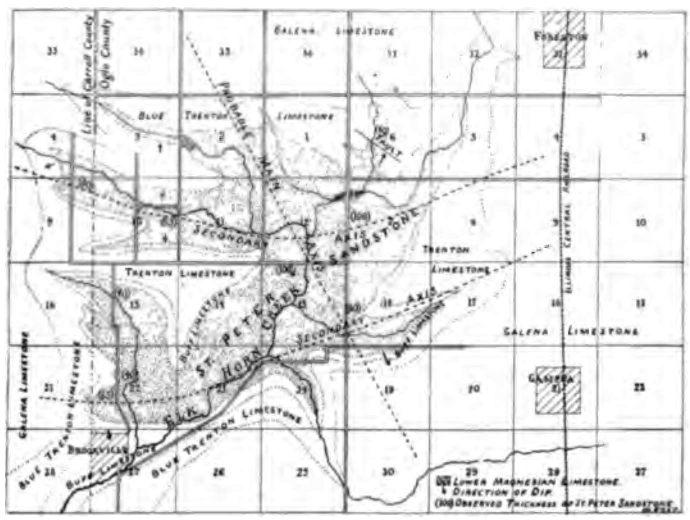


Fig. 1. Map of the Elk Horn creek area of St. Peter sandstone.

ous over hilltop and valley bottom alike. Here and there, however, modern erosion has removed this loess on steep hillsides, especially on the slopes underlain by the sandstone.

The geographical extent of the outcrop of each formation, especially of the sandstone, can be largely determined by the topography alone. Beginning with the Galena limestone rim of the basin (resembling a basin when viewed from surrounding hights), we find it characterized by an undulating topography with comparatively gentle slopes. This has been effected by glacial action. Descending to the Trenton limestone we find the ravines narrower, with steeper slopes, and outcropping rocks more numerous. Still lower, we can readily determine the situation of the sandstone by comparatively narrow, very steep-sided valleys, with all the angles beautifully rounded off, instead of being sometimes sharp and angular as on the surrounding limestone areas. In short, the

sandstone presents the singular phenomenon of resisting erosion well *en masse*, but yielding very readily on angular projections. This is characteristic of the St. Peter sandstone throughout its extent, and it has been commented on by many writers.

It is here proposed to give a short description of the different formations observed in the area covered by the map. But it is presumed that the reader is already well acquainted with their general characteristics as exposed in other outcrops, so that only those features which seem peculiar to this vicinity will be mentioned.

Description of the Rock Formations.

Lower Magnesian limestone. Extending for several hundred yards along the south bank of Elk Horn creek, where it crosses the Freeport and Sterling road two and a half miles southwest of Foreston, there is exposed a formation which is essentially different from the overlying St. Peter sandstone. It reaches a hight of 10 feet above the creek level and presents the following section, in descending order:

	Feet.
1. Brecciated siliceous dolomite apparently broken and re-cemented on a seashore	1
2. Greenish and yellow-brown, argillaceous dolomite, and thin laminated siliceous shales	3
3. Thick, light-buff or yellow stratum of subcrystalline dolomite	1
4. Very thin-bedded siliceous dolomite and chert	4
5. Heavy-bedded dolomite, like No. 3, exposed to the creek level, about	1

The brecciated limestone at the surface of the formation is perhaps the most interesting of all. A stratum of dolomite which was originally laid down and lithified to a compact condition, has been broken up into angular fragments of various sizes reaching as much as one foot or more in length, which have been thrown together in a confused mass and re-cemented, apparently by the same dolomitic substance. The breccia as here exposed averages one foot in thickness, but it reaches as much as several feet in some other places. The contact with the overlying sandstone is not well exposed, but it is presumed to be unconformable. Now of the three chief processes by which limestone breccias may be produced, namely, (1) by pressure, chiefly lateral, as in the Devonian

limestone in Iowa, (2) by the dissolving of some portion of the stratum subsequent to the formation, lithification, and elevation of the rocky strata above sea level, brecciation of the remainder, and recementation, by percolating waters, as in the dolomites of the Ozark series in Missouri, and (3) by the breaking up of a stratum by the waves on a rocky sea shore previous to the deposition of the overlying formations, as in the Lower Magnesian limestone in Wisconsin, the last is considered (after having studied the matter as closely as possible with the very limited outcrop) as the only process by which the breccia under discussion could have been produced.

The two heavy-bedded dolomitic strata, numbers 3 and 5, resemble the Galena limestone and still more strongly the Buff limestone underlying the Trenton proper. But they are more compact, finer grained, and lighter colored than the Galena, and are a purer dolomite than the Buff, which always contains considerable argillaceous material. Furthermore, there is a tendency to develop exfoliation or something similar to it, by No. 5, on erosion. The very thin-bedded silicious dolomite, No. 4 of the section, is characteristic of this fôrmation, nowhere appearing in any of the formations above or below. Enclosed between two heavy-bedded pure dolomite strata, its white, cherty, one inch layers are in strong contrast to them. There are also thin layers of pure sand.

There are indications of fossils, mostly the almost obliterated casts of gastropods, in the dolomite. One imperfect specimen was secured, but the formation may be considered as only slightly fossiliferous.

With what formation of neighboring states may this be correlated? Of the few wells in the immediate vicinity, one at least penetrates the limestone, but not to any considerable depth. So the only means of determining its thickness is the outcrop, which has a vertical extent of 10 feet. It is very probable, however, that it extends down many feet below the creek level. From the outcrops and well sections of the St. Peter sandstone in Illinois and neighboring portions of Wisconsin, no intercalated stratum of limestone or shale has ever been reported. Nor does it at all seem probable that here in this one small spot in the early Silurian sea, dolomite and shale would be deposited, while sandstone was being laid

down for hundreds of miles in every direction. On the contrary, whenever, in passing downward through the St. Peter sandstone, the limestone is reached, it is classed as Lower Magnesian or Calciferous limestone, and the sandstone beds which are intercalated with it as Calciferous sandstone. I shall follow this classification here for the following, in addition to the above reasons. The dolomite, shale, chert, and breccia here discussed, are an exact imitation of portions of the Lower Magnesian of Wisconsin and Missouri. Moreover, the same erosion interval appears to be present here as has been shown to exist in Wisconsin between the Lower Magnesian limestone and St. Peter sandstone. A slight noncönformity is doubtless proven by the phenomena of the breccia; but a greater unconformity is inferred from the following facts: Over the highest part of the dolomite exposure the sandstone is about 75 feet thick. To the south and west the sandstone sometimes reaches 100 feet or more above the creek, and yet the creek bed shows sandstone. Also, a short distance east of a 6 foot exposure of the dolomite it was only reached in a well at 30 feet below the creek level, although both dolomite and sandstone are apparently nearly horizontal at this place. Furthermore, the St. Peter sandstone is 207 feet thick in Stephenson county to the north, and about 200 feet thick at the outcrop on Rock river. It is evident that there is considerable variation in the thickness of the sandstone in this portion of the state. But the upper surface of the sandstone appears to be nearly even; hence it must be the lower surface whose unevenness produces this variability in thickness. This, of course, is caused by a very uneven surface of the Lower Magnesian limestone, which was most probably produced by subaërial erosion in northwestern Illinois, as in Wisconsin. It must be acknowledged that the evidence supporting the hypothesis of a Cambro-Silurian land surface in Ogle county, Illinois, is very weak; but there must have been one small spot on the site of the present Elk Horn valley that was an island over which the waves broke just previous to the deposition of the St. Peter sandstone.

The altitude of the top of the Lower Magnesian limestone in the Elk Horn valley is about 800 feet above the sea, mak-

ing this the highest point, so far as known, reached by this formation within the state of Illinois.

St. Peter sandstone. This formation, as the map shows, underlies about ten square miles in the valley of the Elk Horn creek and its tributaries. Beginning in the valley of the main stream a short distance southwest of Foreston, it follows the creek to Brookville on the Carroll county line. North from Brookville it occupies the valley of a smaller creek for several miles, and at two or three points passes into Carroll county. From the main body of the outcrop near the Freeport and Sterling road, one broad arm runs west three and a half miles reaching a half mile into Carroll county. The exact boundary of the area is very sinuous, as it is dependent on the ravines and valleys and on small faults which have been detected in various parts of the tract although obscured by the overlying loess.

The St. Peter sandstone has been too often described to require a minute description here. There are, however, some features which may be peculiar to this region. The iron concretions, "like broken iron pots," found in the Wisconsin and Rock river outcrops, are absent. The entire mass has been stained with oxide of iron by percolating waters and is brightly colored, red and yellow predominating. The lowest exposed strata are heavy-bedded and tolerably solid; but the great mass of the formation is laminated and loose. There is a six foot stratum of light green shale near the top, which is persistent throughout the area and is overlain by one or more heavy-bedded, partially lithified strata of white or light gray sandstone, constituting the top of the formation. About the center of the northwest arm of the outcrop there is an exposure in a bluff of 65 feet thickness of sandstone. This locality is interesting because of the beautiful false-bedding. The strata dip rapidly in all directions. One portion may dip south as much as 30°, and the sandstone immediately above it may dip north, east or west at the same rate. This confused stratification could not have been produced except near the surface of the sea, and from the fact that the dip is in all directions, it is considered very probable that here was a very shallow spot, perhaps at times a low island or sand bank in the midst of the Silurian sea. Other places also show false

bedding, dipping, however, more decidedly in one given direction. Resting upon the upturned edges of these layers, there is generally one thick horizontal layer of sandstone near the top of the formation. Evidently the subsidence was in progress which resulted in the deposition of the Buff limestone. As already intimated, the thickness of this formation in this area is only from 75 feet to somewhat over 100 feet, while in all directions from it in northwestern Illinois the thickness is not less than 200 feet. It attains an elevation above sea level of nearly 900 feet, a little less than in the Rock river outcrop.

The Buff limestone. This underlies a narrow strip skirting the sandstone on its southern and western side. It is a moderately thick-bedded, buff or light brown dolomite, argillaceous, and nearly free from fossils. Its thickness is about 20 feet, thinning out to the northeast. It passes, by insensible gradations upward into the Blue limestone and downward into the St. Peter sandstone. Hence its lower portion is very sandy and sometimes shaly. Its designation as Buff limestone is deceptive, for under cover it is just as frequently blue as the Trenton above it. Perhaps the term Pecatonica limestone would be more appropriate, as it is best exposed in the Pecatonica valley, near the Wisconsin line, and northward.

Trenton or Blue limestone. This surrounds the sandstone outcrop and is exposed in four quarries and a number of smaller excavations. When drilled through, it is of a deep blue color; but generally on outcrop it is a thin-bedded, light blue-gray or light brown, very fossiliferous limestone and dolomite, with a few very thin layers of shale. In the vicinity of the small fault marked on the northern portion of the map, it is characterized by the vast amount of fossils with which it is thickly packed.

What makes this locality doubly interesting is that, besides the small fault above mentioned, it shows an unconformity or hiatus between the St. Peter sandstone and the Trenton limestone. The very fossiliferous thin-bedded Trenton limestone rests directly on the sandstone, the Buff limestone, which separates them around the south and west boundary of the area, being here absent. The upper stratum of the sandstone is a loose, unstratified mass, about two feet thick, which is com-

posed of sand and clay, with no calcareous material. Now, the St. Peter sandstone in this region is always distinctly stratified and free from clay. This particular stratum is more like the geest or residual material which has collected over the sandstone in the Driftless Area. Moreover, it contains reddish brown oxide of iron in patches, which iron stain resembles that found in surface clays at the present day, and differs decidedly from the iron stains so common in the sandstone. Over this loose sand there are a few inches of dark brown stratified clay, which would be exactly imitated were our present black soil washed away and redeposited by currents of water. Over this lies the fossiliferous Trenton limestone. Nowhere in this region have I found such strong evidences of a land surface and soil in Silurian times. The Trenton limestone is here about 40 feet thick. The Buff limestone is present as indicated by outcrops and well sections, in all directions from this locality. As there is no stratigraphic break between the sandstone and Buff limestone when it is present, the land surface here shown to have existed must have been small, probably an island a few square miles in area. Similar spots of absence of the Buff limestone have been reported from the Rock river area and other places in northwestern Illinois, and there thus seems to have been a slight but extended disturbance in this region during the earlier portion of the Trenton period.

The Galena limestone. This underlies all the higher upland country, but it is scarcely anywhere exposed. Its thickness here is not over 100 feet, while in Stephenson county to the north it is 160 feet, and about Galena and Dubuque 350 feet.

Deformations of the Area.

The area whose geology is under discussion is crossed by three anticlinal axes. The main axis trends from northwest to southeast and is a continuation of the Grand de Tour—La Salle anticlinal, which is the chief axis of northern Illinois. This anticline in the Elk Horn district is not very prominent, the strata dipping in both directions from the crest at a rate not exceeding 30 feet per mile. This alone could not have brought the St. Peter sandstone to light; but it is the intersection of this with two east and west anticlinals which has so elevated the formation that stream erosion has laid it

bare. These two secondary axes are so close together that the synclinal trough between is almost imperceptible. It is rather to be described as a flat-topped uplift from one to two miles wide, with a slight axis or ridge at either side of it. But from the fact that these two bordering ridges diverge and become more easily distinguishable to the west, I prefer to consider them as two anticlines. They sweep across the district in slightly curved lines, trending in a general east and west direction, and concave to the north. On a line directly south from the city of Freeport, the curvature is rather more decided than further east or west, the axes there turning from a slightly south of east to a slightly north of east direction. It has been observed that all the deformations of this portion of Illinois which come in by gently curved lines from Iowa turn rather abruptly toward the east-northeast on or near this same north and south line. From this fact, and because there was sometimes a small island and always an ascent to an elevated part of the sea bottom on the site of the present Elk Horn valley, it is inferred that this line occupies the position of the crest of a southern prolongation of the ancient area of uplift which has been frequently denominated the "Isle of Wisconsin." This, in the subsequent reëlevation and corrugation of the territory, would determine the position of the most southern point of the various anticlinals which Chamberlin, McGee, and other geologists have shown to sweep around the Isle of Wisconsin in approximately concentric courses.

Of the two east and west anticlines crossing this area, the northern one is the most prominent. The dip on the north side is about 100 feet per mile, or 1.7°. This is soon decreased to about 40 feet per mile and so continues six miles to the axis of the next synclinal, which lies on the Stephenson and Ogle county line. This synclinal is occupied by an upland ridge, underlain by Niagara limestone, the edge of which is only four miles distant from the outcropping sandstone, and less than 100 feet higher. The westward prolongation of the anticline is occupied by the valley of Carroll creek, where Hon. James Shaw, in his "Geology of Northwestern Illinois," describes a slight axis. Eastward from this area, the position of the valley of Leaf river was probably largely determined by this anticline; for it is the rule in this part of the

state that the streams occupy the anticlinals, and the larger upland ridges the synclinals.

As already intimated, the dip between the two secondary axes of the area is very slight. But on the south side of the southern anticlinal the dip averages 120 feet per mile or 2.04°. This, however, is not continued far, as the strata soon rise into another anticlinal.

Besides these regular deformations, there are numerous local disturbances, the chief of which are small faults. One only will be described. This is two and a half miles southwest of Foreston, and the exposed portion shows the dislocation of the St. Peter sandstone and Trenton limestone. The strike is northwest to southeast. The dip is about 30° to the southwest. The downthrow is on the southwest side (on the anticlinal side), and amounts to 40 feet. This small fault is noteworthy, from its being the only one in this portion of the state where the actual contact can be observed.

SUMMARY.

The history of this area, and its features of special interest, may be summed up as follows:

History. (a) Deposition of the Lower Magnesian or Calciferous limestone. (b) Probable elevation above sea level and erosion of valleys. (c) Existence of a small island lying off the southern point of the Isle of Wisconsin. The waves beat about this island and over it, forming a thin breccia. (d) Deposition of the St. Peter sandstone. The sea in the vicinity of the now submerged island was shallow, and at times one or more sandy islets may have existed to the west of the old island site, as indicated by the irregular stratification. (e) Deepening of the sea and the formation of the Buff or Pecatonica limestone, accompanied by a slight elevation in the northeastern portion of the area, forming a small island. (f) Slight erosion and slight soil production on this island. (g) Decided submergence of the entire region, and deposition of the Trenton, Galena, Cincinnati, and Niagara strata over it. (h) Last elevation above the sea level, accompanied by the formation of slight anticlinals and many small faults. (i) Erosion of the present valleys.

Features of special interest. (a) The parallelism of the Lower Magnesian limestone of Wisconsin and the Elk Horn

area in their superior member consisting of breccia, and in there being a well marked erosion unconformity at its surface in Wisconsin and an inferred one (supported by some facts as noted) in northwestern Illinois. (b) The similarity, in lithological constitution, between the Lower Magnesian limestone outcrops seen by the writer in Missouri and in the Elk Horn area, both displaying several features peculiar, as I believe, to this formation. (c) False-bedding is rare elsewhere in the St. Peter sandstone, but is common in this area. (d) Deposits at the contact of the sandstone and Trenton limestone which seem to indicate conditions of soil formation. (e) The confirmation of Mr. W J McGee's suggestion, in his memoir on the "Pleistocene History of Northeastern Iowa," that the elevation of the strata to such a degree as to permit the St. Peter sandstone to outcrop at several points in Illinois is due to the intersection of different members of a system of parallel undulations, developed in Iowa and continued eastward in Illinois, with the Grand de Tour-La Salle anticlinal.

HISTORY OF INSTRUCTION IN GEOLOGY AND PALÆONTOLOGY IN GERMAN UNIVERSITIES.*

By KARL A. VON ZITTEL, Munich, Bavaria.

In the fundamental researches of the preceding and the beginning of the present centuries, by virtue of which Geology and Palæontology rose to the dignity of independent natural sciences, German institutions bore only a very insignificant part. The higher academies of that period could boast as a rule of but a single professor of natural history, who usually combined instruction in botany and zoology, and sometimes also in mineralogy. The work of the modern field-geologist and topographer was carried on in those days merely by mining engineers, to whom, indeed, we are indebted for the first truly scientific reports on the areal geology of a region. Lehmann (1736) and Füchsel (1762) published as long ago as the last century the results of their observations on certain mining districts in Thüringia, established and defined the idea of "formations" (as for example the Kupferschiefer, Zechstein, Rothliegendes, etc.), and worked out the stratigraphy for the Thüringer states. Füchsel even went so far as to attempt a cartographical delineation of his observations, and this, the first geological map ever constructed, he proceeded further to elucidate by means of profiles. The

*Translated, with permission of the author, from *Die deutschen Universitaten* (edited by Prof. W. Lexis, Berlin, 1894), by Charles R. Eastman, Ph. D., Saint Paul, Minn.

practical significance of these investigations, however, was not fully appreciated until Abraham Gottlob Werner (1750-1817), professor of mineralogy in the Freiberg School of Mines, extended Füchsel's conception of a geological formation and used it as a basis for his theory of the composition of the earth's crust. Werner's remarkable ability and magnetism as a teacher were the means of kindling an enthusiastic interest in the new science all over Germany; and from the little mining town in Saxony there emanated a new intellectual movement which spread even into foreign countries, where it met with strong and talented supporters in such men as Hutton, William Smith, Dolomieu, Cuvier, Brongniart, de Saussure and others, who had devoted themselves to the study of geology and palæontology. Although Germany justly prides herself on possessing in the first decade of the present century three of the greatest and most illustrious minds in geology, Werner, Alexander von Humboldt, and Leopold von Buch, nevertheless neither they nor their able coadjutors (von Freiesleben, Heim, von Hoff, von Schlotheim, Count Münster, Heinrich Credner, Hermann von Meyer and others) belonged to university circles, but were either independently situated or were engaged in other pursuits as well.

Not until the second and third decades of the century, after the fundamental principles of geology had become well established, did the universities begin to participate in the further development of the science; they soon took the lead, however, and have maintained their precedence ever since. The first chair devoted exclusively to mineralogy (held by Ch. Weiss) was founded in 1808 in Berlin, and this example other universities were not slow to follow. Instruction in geology devolved entirely on mineralogists, while palæontological investigations remained in the hands of zoologists and botanists. That Berlin, in consequence of the powerful influence of Alexander von Humboldt and Leopold von Buch, should have stood so long in the very foremost position, was really less due to the efforts of the University itself than to a younger body of highly gifted, enthusiastic workers, who, stimulated and directed by the two great masters, pushed out in all directions in geology, and founded in *Karsten's Archives* a valuable organ for their communications.

It was not long, however, until nearly every higher academy in Germany was provided with a full professor in mineralogy, and pains were taken to secure all sorts of aids to instruction; especially suites of rock specimens, ores, and fossils; and at the same time, owing to the rapid strides being made in geology, a division of labor became necessary. After the physiography of the various minerals had been investigated with some degree of thoroughness, mineralogy sided over more nearly in line with chemistry and physics; while geology was understood as applying more particularly to palæontology and lithology, together with the problems of vulcanism, mountain-making, and general dynamic geology. The difficulty of properly directing the steadily augmenting numbers of geological disciples became more and more serious, so that first in Munich (1843), then in Berlin, and before long even in the smaller

universities, a second either full or assistant professorship in geology and palæontology was established in addition to that in mineralogy. At present there are three full professors in Berlin and two in Bonn, Göttingen, Leipzic, Marburg, Munich, and Strassburg; most of the other universities retain a full professor in either geology or mineralogy, and an assistant professor in palæontology. On the individual accomplishments and the special services rendered to science by many of the occupants of these chairs is based the claim which German universities have to make on the building up and furtherance of geology and palæontology.

Among the older institutions of Prussia, Berlin was from the first the best equipped in facilities for instruction, in rich collections and libraries, and in a strong corps of teachers. The researches of Gustav Rose, Rammelsberg, and Justus Roth in lithology, chemical geology, and vulcanism, the fruitful inquiries of E. Beyrich in the department of structural and historical geology, together with his geological reconnaissance of Silesia and the base of the Hartz, the pioneer investigations of Ehrenberg on microscopic rock-building organisms, both recent and fossil, as well as the unfortunately too scantily recognized work of Oschatz in the construction of microscopic sections of minerals and rocks, all contributed to make Berlin, even after the death of Leopold von Buch, a leading center of geological and palæontological research. In December, 1848, the *Deutsche Geologische Gesellschaft* sprang into being; and with it a periodical was founded, which down to the present moment has continued to exercise a most powerful influence on the growth of geology and palæontology.

Bonn vied for a long time with Berlin for the precedence. By a fortunate coincidence there was gathered here, about the middle of the century, a notable company of scientists, such as Nöggerath, Bischof, Goldfuss, Ferdinand Roemer, Mohr, Gerhardt vom Rath, Volgelgesang, Zirkel, and von Dechen, director of mining industries, all of whom were highly prominent in their various specialties. Von Dechen's geological atlas of the Rhine country and Westphalia, which appeared in 35 sheets on a scale of 1 : 80,000, and was accompanied by two volumes of text, was the first geological map of a considerable part of Germany executed on a large scale. It remains to-day a remarkable instance of precise observation, and builds the foundation of all subsequent surveys. The publication of von Dechen's *Geognostische Uebersichtskarte von Central Europa*, in 1869, rendered the results of geological investigations universally accessible. Ferdinand Roemer's *Rheinisches Schiefergebirg*, and Goldfuss's *Petrefacta Germaniæ*, will endure as noble monuments to the patient industry and accuracy of German investigators; while G. Bischof's renowned *Lehrbuch der physikalischen und chemischen Geologie* opened up in an original manner a new and quite unexplored territory, and affected a permanent modification of the current theories of volcanic action and the origin and metamorphism of rocks. In Bonn also originated the modern reform in petrography. The light thrown by H. Clifton Sorby's investigations into the microstructure of

rock-forming minerals was first recognized in its true significance by Ferdinand Zirkel (now of Leipzic), whose further development and refinement of the subject put an end to the long period of stagnation in petrography. At the head of the modern school of petrographers stands first of all Zirkel, alongside of whom Rosenbusch and Cohen (of Heidelberg and Strassburg) are none the less conspicuous, not only on account of their penetrating researches, but also for having devised most skillful means for bringing the principles of physics and crystal-optics to bear on the microscopic analysis of rocks.

The University of Halle, Prussia, where Germar, Fr. Hoffman, Keferstein, Girard, and von Fritsch were engaged as geologists, and Giebel and Burmeister as palæontologists, lays claim to important services in the advancement of geology and palæontology. Breslau, since its calling, in 1855, of Ferdinand Roemer, the leading authority on Palæozoic formations, to a professor's chair, has been the training school of a large number of Germany's ablest and for the most part still living geologists and palæontologists, such as von Seebach, Schlüter, Hermann Credner, Eck, Dames, Tietze, and numerous others.

The beginning of the present century found a vigorous scientific life pulsating in Göttingen University, Hannover. The ideas of Werner, Alexander von Humboldt, and Leopold von Buch fell here on fertile soil. While Blumenbach had early grasped the important significance of fossils as means for identifying different strata, his successors, Hausmann, whose investigations were by no means confined to mineralogy alone, Sartorius von Waltershausen, and C. von Seebach, rose to a still higher degree of influence among German geologists. Sartorius in particular, through his monographs on Etna, on the physical geography of Iceland, and on the climatic conditions of former periods, enriched science with works of rare learning and of permanent value.

Among the universities of central and southern Germany, those in Heidelberg, Leipzic, Munich and Tübingen are the most important. Heidelberg commanded, as early as the third decade of the century, an advanced position in the lines of geological and palæontological progress. In the person of C. C. von Leonhard, compiler of the *Mineralogischen Taschenbuch* and founder of the *Neues Jahrbuch für Mineralogie, Geologie, und Petrefaktenkunde* (which, together with the *Zeitschrift der deutschen geologischen Gesellschaft*, is the most important of all periodicals in geology and palæontology), the university posessed a lecturer of charming eloquence, and a brilliant student of volcanic action and eruptive rocks. By his side stood H. G. Bronn, professor of zoölogy and palæontology, a man of prodigious scholarship; his *Lethæa Geognostica* is one of the bulwarks of geological and palæontological literature, while his *Geschichte der Natur* and *Index Palæontologicus* were for many years most indispensible requisites for every worker in palæontology. The petrographical studies of R. Blum also occupy an enviable position in the geological literature of Germany.

In Leipzic, beginning with 1842, C. F. Naumann lectured in mineralogy and geology for thirty consecutive years, after having already

served sixteen years as professor of crystallography and geognosy in the Freiberg School of Mines, where he won renown for his excellent crystallographic and mineralogical researches. While at Freiberg, also, he had been engaged with Bernhard von Cotta in the construction of a geognostic map of Saxony, which was published on a scale of 1:120,000 and exercised an immense influence on the growth of the mining industries, especially in the coal regions of Saxony, and rivalled in point of accuracy von Dechen's map of Rhineland and Westphalia. But Naumann's crowning geological work is his *Lehrbuch der Geognosie*, universally recognized as the most thorough and comprehensive treatise on the subject and which remained for decades the one ideal handbook for every student of geology. Naumann's exceptional ability as a teacher made Leipzic an important center for training in mineralogy and geology; nor were the old traditions swept away at Naumann's death, which occurred in 1873, since his mantle fell on two such worthy successors as F. Zirkel and Hermann Credner, the latter of whom is the author of the best shorter textbook on geology that exists, and is director of the Saxon Geological Survey. In the study of palæontology, however, Leipzic offers but few advantages, although the botanist Schenk, together with Schimper, Geinitz, Weiss and, more recently, Count Solms-Laubach (Strassburg), has rendered most valuable service in enlarging our knowledge of fossil plants.

Of the three Bavarian universities, Munich led the way by beginning in the second half of the century to take a lively interest in geological and palæontological discoveries. The rich collections of the Royal Academy of Bavaria, after the removal of the university from Landshut to the capital, were placed in the custodianship of a university professor, with the privilege of their being used for educational and other scientific purposes. Schafhäutl was the first full professor of geology appointed (1843), who devoted himself chiefly to the investigation of the then almost wholly unknown geology of the Bavarian Alps, while A. Wagner, professor of zoölogy, took charge of the palæontological work. Later, however, as W. Gümbel began his career as scientist, university instructor, and director of the State Geological Survey, and little by little as the results of his forty years' experience in the exhaustive study of the geology of Bavaria were published in his great work (*Geognostische Beschreibung der bayerischen Alpen, des ostbayerischen Grenzgebirges, des Fichtelgebirges, und fränkischen Jura*), and as at the same time Alb. Oppel entered upon his brief but most successful period of instruction, Munich became more and more prominent as a training school in geology and palæontology, and during the last thirty years has turned out a goodly number of some of the ablest younger geologists and palæontologists, such as Benecke, Waagen, Schwager, Schlönbach, Neumayr, von Sutner, Branco, Naumann, Vacek, Pohlig, Böhm, Steinmann, Penck, Rothpletz, Walther, Gottsche, von Ammon, Schlosser, Reis, von Wöhrmann, Jaekel, Eberhard Fraas, and others.*

[*The extreme modesty of the author forbids even the bare mention of his name in connection with the University he has served so well. It is, however, scarcely necessary to add that the pre-eminence which Munich enjoys to-day, among European training-schools in geology and palæontology, is due almost wholly to the rare ability and influence of our master in these sciences.—TRANS.]

In Tübingen, F. A. Quenstedt (1809-1889), one of the most original, broad-sided and capable of German geologists and palæontologists, taught for over half a century. His tireless energy in investigating the geology of Württemberg, and in particular the Schwäbian Jurassic, his rare talent for instruction, and his reputation as an exceedingly close observer, created for him such respect, not only on the part of his hearers and special students, but of a far wider circle as well, that his name attained a wonderful popularity and the general interest in geology extended even to social classes which in all other respects hold nothing in common with science. In many a neighborhood in the Schwäbian Alps one meets with common peasants who are fond of collecting fossils, are perfectly familiar with Quenstedt's subdivisions of the Jurassic and with a variety of other geological facts. Quenstedt's career is an eloquent example of what truly valuable service a single enterprising spirit can render, although commanding but the most limited resources: nor is his example by any means unique in Germany. Nearly all the universities above mentioned, not excepting even the smallest, can boast of at least one or more professors in geology, such as Dunchér, von Klipstein, Fr. Sandberger, Pfaff, Streng, Kayser, von Koenen, Laspeyres, Johann Lehmann and others, who have especially signalized themselves either as educationalists or as investigators.

During the last three decades geological bureaus have been instituted in nearly all the states of Germany, and in consequence a large share of the practical work formerly carried on in connection with universities has been absorbed. At the same time, however, these bureaus are as a rule placed under the direction of university professors, to whom in fact their initiation is usually due. The chief field of usefulness which modern universities subserve consists in the giving of instruction, in the higher theoretical training offered to younger specialists, and in the opportunities for conducting original research work. With the ever widening scope of the science, with the fairly overwhelming amount of working material and with new and refined methods of research, the necessity of changes and improvements in the mode of instruction becomes self-evident. The functions of the modern university professor are by no means restricted to lectures and excursions, but it is also of the utmost importance that the beginner should have the actual working material and the literature placed in his hands, should gain practical experience in various methods of research, and should be entrusted with original research work under the instructor's direction. The proper fulfillment of these conditions presupposes, of course, a thorough equipment in libraries and museums, and the introduction of some such arrangement as one finds in chemical laboratories for example, where both beginners and advanced students find an opportunity for engaging in individual laboratory work. Institutions of this character are to be found in connection with most German universities of the present day, all differing more or less from one another, however, according to the means at disposal and according to the various scientific specialties of the individual instructors. While, for instance, in Leipzic, Heidelberg and

Greifswald the petrographical side is more especially cultivated, on the other hand the universities of Munich, Berlin, Strassburg, Breslau, Bonn, Göttingen. Halle and Tübingen, partly because of their rich collections and partly on account of their excellently organized and well equipped special Institutes, offer the best advantages for palæontological training. In the smaller universities, where the number of geological students is naturally limited, laboratory accommodations may be reduced to one or two rooms, and in some cases the students' working-collections are also placed here. In the larger institutions students in the elementary and in advanced courses work apart from one another, and the amount of space occupied is necessarily much larger. The instrumental outfit consists mostly of microscopes, various kinds of saws, grinding and polishing machines, and other necessaries for the construction of microscopic sections.

If one will compare the advantages offered by German universities for the special pursuit of geology and palæontology with those existing in similar foreign institutions, the conclusion cannot be avoided that our institutions are by no means behind the others in point of excellence, but, on the contrary, that they and their methods may well serve as models for other countries to pattern after.

EDITORIAL COMMENT.

"The Mineral Industry."

The Scientific Publishing Company has recently issued its second volume under the above title. Aside from its title, which is a misnomer, the work is very creditable and valuable. Such a title would lead a geologist to look for the statistics and methods of dealers in minerals, such as Geo. L. English or A. E. Foote, who have been known for many years as leading mineralogists and who have sent their consignments to nearly every college in America. But their names are nowhere to be found in the volume, at least they are not in the index. It has to be explained that this volume is not devoted to minerals, but to the mining of such minerals as are of economic value, and to the methods of getting them into the markets, either in a raw state, as ores, or in a refined state suitable for the hand of the manufacturer.

In the early years of a new country the energies of the settler are devoted necessarily to the quickest and easiest means of winning a comfortable subsistence, and that makes him a tiller of the soil. He becomes a manufacturer and a trader later, and last of all he becomes a miner. The United States

is just entering upon this last stage and has made considerable progress in it. This development of the economic side of geology has been very rapid in America within the last fifteen years, and it foretells for the future such changes from our present methods of industrial economy that when they are fully established they will revolutionize many of the conventional ways of modern society. The discovery of the means to control electricity will lead directly to the employment of water power to execute most of the costly work at the mine. With a cheapening of the work will go an extension of the product of the mine, and this will extend the mining industry in all its ramifications.

The American Institute of Mining Engineers has been the head and front of this rapid growth of the mining interests amongst the practical geologists of the country. It represents the best organized system for bringing together for comparison and for preservation the results and methods of the scientific miners of the United States. Its establishment marked an epoch in scientific mining in America. Its published volumes are among the most valuable geological works of the day. Here the theoretical systematist in geology will find his theories put to the unfailing test of practice. It is not too much to say that to the miner, and hence to the mining industry, geology must look for most of its future progress, at least in the United States. In Canada the economic side of geology has always been put to the front and systematic geology has been comparatively neglected. The reverse has been the case in the United States. The example of New York State, which has entirely neglected, officially, its economic resources and has spent much upon the technical and paleontologic aspects of geological science, has been followed by too many of the state surveys and too closely by the United States survey. Economic geology has made headway in spite of this indifference. Speculative and technical geology has had the field for many years, but it becomes more and more apparent that room must be made for an extension of that phase of the science which directly concerns the greatest number of people.

The second epoch-marking event in this progress is the establishment of the publication which is above referred to. The United States Geological Survey has made an effort to

publish the statistics of mining in the United States from year to year, and its annual reports on statistics have furnished a record of a mass of information which is valuable and must be preserved for future use, but they have been published so late that they have been cheated out of their chief value, which centers in the present use that can be made of such information. They are like the reports of the Smithsonian Institution, coming after the information which they convey has become old, and has been seen and used by the need of the times long before. The tortuous and time-taking "red tape" of the government is in this volume cut into fragments and a result is reached before the government fairly begins its task. "Belated statistics are ancient history, of little practical value in the active affairs of an industry, or as a guide for legislation affecting it." Private interests were therefore the first to feel this defect and the first to remedy it. The result is sufficient testimony to the need of such earlier publication, and a sufficient warrant for the U. S. Geological Survey to withdraw entirely from this field unless it be in terms ordered by law to continue. The decennial census would supplement this publication sufficiently, and would correct such errors as may be found incident to hasty work.

The volume, however, is not made up of statistics. It is a first class treatise on economic geology. Its writers are experts in the lines in which they have contributed information, and have treated fully of the ores, as to mode of occurrence, means of extraction, geographic distribution, metallurgical processes, values at the markets, exports and imports, uses, and total production. The various mining schools of the United States are described and the value of geological surveys is indicated briefly. The work emanates from New York, that throbbing heart of the continent's commerce. N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Illustrations of the Fauna of the St. John group. No. VIII. G. F. MATTHEW. (Trans. Roy. Soc. Canada, 1893, sec. IV. pp. 85-129. 2 plates.) The long and highly interesting and successful researches of Mr. Matthew into the fauna of the St. John group are in this paper brought to

a formal close. It includes a survey and summary of the work from the beginning to the end, the fossils being all named in tabular arrangement and referred to their stratigraphic positions in the series. The strata that contain these fossils are composed of four main parts, viz:

	Feet.
Basal series (Etcheminian) at Hanford brook, St. Martins	1,200
Division 1 (Acadian) at the Alms House, Simonds	650
Division 2 (Johannian) at King's square, Carleton	1,000
Division 3 (Bretonian) at Straight shore, Portland	700
Total thickness	3,550

Of these the Etcheminian, which is below the St. John proper and separated from it by some evidence of a plane of erosion, is perhaps the representative of the Olenellus horizon. From it, however, only a very sparse fauna has been obtained. The strictly primordial trilobites are confined to division 1, of the St. John group proper, in which bands *c* and *d* are characteristically a Paradoxides horizon. No species of Olenellus is listed. Division 2 is practically non-fossiliferous, having afforded only tracks, burrows and trails. Division 3, however, has in one of its bands near the top, a large number of graptolites which are thought to ally the beds of this division with the Lower Silurian (Ordovician) horizon (AMERICAN GEOLOGIST, XII, pp. 193, 340). With these are brachiopods and a number of trilobites, the latter being Agnostus bisectus, and A. trisectus, Parabolina spinulosa, heres, and grandis, Parabolinella posthuma, Protopeltura acanthura var. tetracanthura, Peltura scarabeoides, Cyclognathus rotundifrons, Leptoplastus latus and spinosus, Ctenopyge flagillifera, acadica and pecten, Sphærophthalmus alatus var. canadensis, and Conocephalites contiguus, and two unknown species. It may be questioned whether this fauna should not be kept within the Upper Cambrian, as that term is used by most American geologists, rather than extending the term Ordovician or Lower Silurian downward so as to cover it. The term Ordovician was devised to cover those beds which were in dispute between Sedgwick and Murchison, and they were the Bala and Llandeilo, the American Hudson River and Trenton, and to these it would seem legitimate to confine the term. The above fauna is lower than the true Ordovician, and comes more nearly at the horizon of the St. Croix, or Upper Cambrian. N. H. W.

Contribution to the Knowledge of the Preglacial Drainage of Ohio. By W. G. TIGHT. (Bulletin of the Scientific Laboratories of Denison University, vol. VIII, pp. 35-62, with five plates, June, 1894.) In this article Prof. Tight has published the results of some of his observations on the glacial geology of the district near and around Granville and Newark, Ohio. It would not be easy to find a more complicated spot than the gorge of the Licking river between Newark and Zanesville; and the author's explanation of the history of the changes that have produced this gorge, or rather these gorges, seems natural and necessary. He traces three distinct and successive channels of the river consequent on the conditions caused by the presence of the ice-sheet and of the morainic matter left on the surface when the ice retreated. The ponding back

of the water of the Muskingum by the eastern edge of the Scioto lobe of the continental glacier caused that river to desert what the author regards as its preglacial channel and to take a new one along its present course. The deposit of huge moraines across the same preglacial channel produced a lake covering the site of the present Licking reservoir, which was ultimately drained by the cutting down of its eastern barrier. The figures accompanying the paper will enable any glacialist to comprehend the author's reasoning, but only a visit to the spot can show its full force and significance.

In the second part of the paper the author ranges over a much wider field and attempts a reconstruction of the preglacial hydrography of Ohio which is both novel and striking, but which, in spite of some strong points, geologists will be slow to adopt, at least in full and without modification. He traces the preglacial Muskingum from its present channel at Dresden southwestward to Newark along a wide abandoned valley and then through Fairfield county into the Scioto basin. Thence he carries it to the west and northwest through Madison and Champaign counties into the Wabash drainage system in Indiana. This view certainly affords an explanation which no other has done of the very deep drift-filling along the line in question, and especially of the immense mass of drift at St. Paris, where it is more than 500 feet thick. But it compels the blotting out of the Ohio as a continuous channel, and renders necessary the adoption of the view that the present valley of that name is made up of parts of several preglacial valleys united by glacial and postglacial cross-cuts. This will scarcely commend itself to glacial geologists without very strong evidence. The task is too vast for postglacial time. Possibly some modification, however, may remove the difficulty and allow the abandonment of the Wabash channel at a earlier date and the establishment of an Ohio before the Glacial period began. We should like to suggest to the author a consideration of some of the possibilities along this line. Change of level in the peneplain during Tertiary time may have been sufficient to produce such an effect, and of this some amount of evidence is already attainable.

Professor Tight quotes the fact that the valleys of the present Muskingum, the Scioto, and other streams of the same region, narrow to the southward, in support of his opinion that their flow has been reversed. The argument is good, but would apply as well to that above suggested.

E. W. C.

On the occurrence of a large area of Nepheline Syenite in the township of Dungannon, Ontario. By FRANK D. ADAMS. (Amer. Jour. Sci., 3, vol. XLVIII, pp. 10-16, July, 1894.) The area described is in Hastings county, in the midst of Laurentian rocks, and this is the first discovery of nepheline syenite in the Laurentian system of Canada. The essential constituents of this rock are nepheline, which often makes up almost the entire rock, albite, and some little brown mica and hornblende. Orthoclase, which is common in rocks of this class, is not found as an original mineral. A noticeable feature of the rock is the occurrence of scapolite and calcite, both rather common and having the appearance of original

constituents. The origin of the calcite is difficult to determine; it is not a decomposition product in the ordinary sense, and it does not seem to fill microlitic cavities. In an accompanying paper Dr. B. J. Harrington gives analyses of some of the minerals of this nepheline syenite.

U. S. G.

Second Expedition to Mount St. Elias, in 1891. By ISRAEL COOK RUSSELL. Pages 91; plates III-XXXI, and six figures. (Advance extract from the Thirteenth Annual Report of the U. S. Geol. Survey, for 1891-'92; Washington, 1894.) The observations made by Prof. Russell, in his two expeditions to Mount St. Elias, concerning the transportation and deposition of till by the Malaspina glacier or ice-sheet and the supply of large amounts of modified drift to the streams of its melting by which they are deposited as eskers, kames, and extensive flood-plains, have greatly stimulated the researches of American glacialists to determine the proportions of the Pleistocene drift borne along respectively in the mass of the ice-sheet and beneath it, and how it acted to heap up the drumlins of New England, New York, Wisconsin, Ireland, and Scotland, and to form the conspicuous esker ridges of Maine and Sweden and, in less abundance, of all glaciated areas. These and similar questions, relating to the genesis or methods of formation of the glacial and modified drift, at present enlist the attention of workers in this field as never before; and for the advancement of knowledge in these directions Profs. Chamberlin, Wright, and others, are now absent in exploration of the borders of the Greenland ice-sheet. By these studies of living glaciers analogous in all their phenomena with the Pleistocene continental ice-sheets, we may hope to attain a much clearer conception of the history of the Glacial period and the origin of its widely diverse and complex drift formations.

A map of the Malaspina glacier and St. Elias mountains shows Prof. Russell's routes in 1890 and 1891. In the second expedition he ascended to a hight of 14,500 feet on the northeastern slope of St. Elias, and explored the western central portion and forest-covered front of the glacier, taking very interesting notes of the streams outflowing from it, named the Yahtse river, Yahna, Fountain, Manby, Osar, Kame, Kwik, and Esker streams. The glacier or ice-sheet covers an area of about 1,500 square miles, having an extent of some 70 miles from east to west along the coast, with a breadth of 20 to 25 miles, and a general elevation of about 1,500 feet five or six miles from its outer border. At Icy cape its Guyot lobe pushes boldly forward into the ocean, and, with its front constantly breaking off to form icebergs, terminates in magnificent ice cliffs estimated to be at least 300 or 400 feet high.

Seen from a distance of several miles, the cliffs of Icy cape appeared to contain no drift, though the surface of the ice there, as all along its borders adjoining the sea, is drift-covered. The surface of the central parts of the ice-sheet, however, is free from drift, excepting along morainic lines streaming downward from spurs and foot-hills of the mountains. Near its border the ablation of its surface seems to uncover much drift which had been borne along in the middle and basal por-

tions of the ice-sheet. Therefore it may be found by closer inspection of Icy cape that much englacial drift, although too small in relative amount to be observable from the east side of the Yahtse river, occurs within the ice-cliffs, such as has become exposed on the surface by progressing ablation. In the vicinity of the Yahtse and of Icy cape, however, the superficial moraines of the Chaix hills are mingled with the less plentiful englacial drift, which latter seems to be the chief source of supply at the Sitkagi bluffs and thence eastward twenty-five miles to the Kame stream.

Professor Russell and his parties in both expeditions braved many dangers and well performed their tasks of geographic and geologic exploration. The narrative and the discussion of scientific results are presented in a most modest and entertaining manner. They mark a stage of great progress in our knowledge of the conditions of the Ice age. W. U.

On Certain Astronomical Conditions favorable to Glaciation. By GEO. F. BECKER. Am. Jour. of Science, III, vol. XLVIII, pp. 95-113, Aug. 1894. From a mathematical investigation of the effects of the unequal amounts of solar heat received by different portions of the earth's surface under varying astronomical conditions, the author sums up his results, differing widely from the well known views of the late Dr. Croll, as follows: "I began this enquiry without the remotest idea as to what conclusion would be reached. At the end of it I feel compelled to assert that the combination of low eccentricity and high obliquity will promote the accumulation of glacial ice in high latitudes more than any other set of circumstances pertaining to the earth's orbit. It seems to me that the glacial age may be due to these conditions in combination with a favorable disposition of land and water. This theory implies, or rather does not exclude, simultaneous glaciation in both hemispheres. It does not imply that the ice age should last only ten or twelve thousand years. If the conditions here suggested are correct, variations in the disposition of land and water may have determined intervals of glaciation, not necessarily the same ones in New England and the basin of the Mississippi; and there may have been considerable time differences in the inception or the cessation of glaciation in various regions. It is not needful to assume that the glaciation of the Sierra Nevada either began or ended synchronously with the ice age in New England. The date at which a minimum of eccentricity last coincided with a maximum of obliquity can almost certainly be determined. According to Stockwell, the obliquity has been diminishing for the past 8,000 years, and was within 21 minutes of its maximum value at the beginning of that time. According to Leverrier, the eccentricity passed through a minimum 40,000 years ago, the value being then about two-thirds of the present one. So far as I know, the obliquity has not been computed beyond 8,000. This can of course be done for Stockwell's value of the masses of the planets, or for newer or better ones. All the indications seem to be that within thirty or forty thousand years con-

ditions have occurred, and have persisted for a considerable number of thousand years, which would favor glaciation on the theory of this paper." Dr. Becker's conclusion is thus closely harmonious with the present reviewer's estimates, as noted in the last May AMERICAN GEOLOGIST (page 364); and it appears that he regards the causes of ice accumulation to consist more in geographic changes, as land elevation, than in the varying astronomic conditions. W. U.

CORRESPONDENCE.

A REPLY TO "CAUSES AND CONDITIONS OF GLACIATION."* "The occurrence of .... late Carboniferous and Permian glaciation .... is inconsistent with Falsan's† and Manson's views, which have no place for general glaciation before the Pleistocene period."‡

It is true that, in the interpretations rendered in *Geological and Solar Climates*, there is no place for general glaciation before the Pleistocene period; nor has it been proved that such general glaciation has occurred. Widely distributed glaciations during Paleozoic time have been shown, but the evidence adduced is such as to warrant the conclusion that such glaciations were local and not general.

According to the principles and views set forth in the writer's work, local glaciation could have occurred at any time during the Paleozoic era, provided the conditions were favorable. That local favorable conditions could have existed, is in no way inconsistent with the views therein advanced. Indeed, such local glaciation is corroborative of one of the prime ideas of the argument, which is, that prior to the Quaternary era surface temperatures were independent of latitude, which independence is distinctly proved by the wide range of Paleozoic glaciations. Had the early local glaciations been dependent upon solar heat, they would have been governed by the same laws of distribution as the glaciations of to-day; and had any general "period" of glaciation occurred, it would have been accompanied by arctic types of fossil life, such as accompanied the general Quaternary glaciation, the distinguishing test between local and general glaciation being fossil marine life of a cold temperate or arctic character. All the evidences of early glaciation yet discovered are mechanical, i. e., boulder transportation, striæ, etc.; and they occur in such varying latitudes as to distinctly prove that the climates were absolutely independent of latitude. Therefore the Permian and Carboniferous glaciations corroborate the view set forth in *Geological and Solar Climates*, that prior to the Quaternary era surface temperatures were independent of latitude, being controlled by local conditions of elevation and conductivity of the crust.

Again, on page 17, there occurs this objection: "Another obstacle

*AMERICAN GEOLOGIST, July, 1894, pp. 12-20.

†It is unnecessary to call attention to the difference between the views of Falsan and those of the author.

‡Loc. cit., pp. 16, 17.

to Manson's hypothesis* of a continuous cloud envelope till after the Quaternary glaciation, consists in the extensive deposits of rock salt and gypsum found in strata as old as the Silurian and Cambrian, *since these beds could only be formed by evaporation of lagoons shut off from the sea, or of saline lakes, under a drying atmosphere.*" (Italicised by the present writer.)

The physics and chemistry of this objection are defective. Even upon the assumption that the vast beds of gypsum, rock salt, or other minerals deposited from aqueous solution, were solely the result of evaporation, it does not follow that such deposition was the result of an absolute, nor even partial, desiccation of the basin containing the solution. The deposition of soluble salts goes on from saturated solutions under any evaporation at all, and if the water flowing into the basin had been already saturated at a higher temperature, the deposition of the salt would go on even with increasing depth of water in the basin, by the cooling effect of evaporation.

It is at least possible that vast beds of gypsum were precipitated by the commingling of solutions of a more highly soluble salt of lime with a solution of sulphuric acid or of an alkaline sulphate; in which case the precipitation of gypsum would go on independent of evaporation, and drainage entering the body of water from different areas might have supplied the solution necessary to continue the precipitation for some time. In the same way other salts could be formed to such an extent as to be present in greater quantities than would saturate the solution, and hence they would be precipitated or crystallized out.

The precipitation of sulphate of lime would go on in the Pacific ocean to-day, provided there were discharged into its waters any soluble salt of lime and an alkaline sulphate sufficient to charge its waters with more than about 1-400 of sulphate of lime.

Many of the compounds of sulphur and chlorine with the non-metallic elements are volatile, and they may have been, and doubtless were, present in the atmosphere during earlier ages to a greater extent than at present. In that case, such compounds would be washed out of the atmosphere by rains, and coming in contact with solutions of the alkaline earths and alkalies would form and precipitate or crystallize out the more stable salts now in existence. The formation of sulphate of lime, common salt, etc., would then proceed from abundant rains rather than from a period of dryness and excessive evaporation: the less soluble salts would be precipitated as formed, and the more soluble ones would crystallize out from saturated solutions. It therefore does not follow that "these beds could *only* be formed by evaporation of lagoons shut off from the sea, or of saline lakes, under a drying atmosphere."

Another argument, used more to show that the Ice age was caused by the upheaval of temperate land areas than as an objection to the criti-

*The writer disclaims any attempt to advance an hypothesis or assumption of any kind, but simply endeavors to make an interpretation of natural facts upon the basis of known and admitted laws. He does not even assume that the cloud envelope was removed, but that its removal was geologically and physically recorded. *Geol. and Solar Climates*, pp. 39 and 49.

cized interpretations, is that the submerged channels off the mouths of certain rivers are evidence that such submerged channels are the results of erosion, and therefore that they marked periods of upheaval and depression of adjacent lands. Whilst this may be true in some instances, it by no means follows for all, nor for the deeper of these submerged channels.* Channel-building by bank elevation goes on as well under water as under air.† The sediments which these rivers have borne to the ocean during their entire existence (and particularly during the "Diluvial" and "Terrace" epochs) must have been deposited more upon the flanks of the outflowing fresh water than in the direct lines of swiftest flow. If any one will take the pains to plat to natural scale the sections of many of these deeply submerged channels, he will find that the slopes of the banks are not upon lines of erosion, but that they correspond more nearly to lines of sedimentation. Besides, before a submerged channel shall be decided to be one of erosion, not only should the form of the channel correspond to proper lines, but the material of its banks should be determined, and the eroded materials should be accounted for either in the extension of the bank lines or in the construction of a bar at the eroded mouth. Therefore, the existence of a submerged channel is not always a proper and conclusive proof that the channel was formed by erosion and hence is evidence of great upheaval and depression of adjacent lands. MARSDEN MANSON.

San Francisco, Cal., July 24th, 1894.

LAKE CAYUGA A ROCK BASIN. Replying to Dr. Spencer's comments on my paper which states the evidence at hand pointing toward the conclusion that lake Cayuga is a rock basin, I would say that my failure to include the continental tilting of the land was due to the fact that it would not essentially modify the argument, and that I have not considered the conclusions reached as definite enough to be accepted. Some tilting has taken place, but much needs to be done before we can determine its amount in central New York. The problem is complex and requires a knowledge of the preglacial and the glacial attitude of the land, as well as the postglacial changes.

I do not deny that rock exists at a considerable depth near the outlet of lake Cayuga; indeed, I should be surprised if this were not the case. I cannot, however, agree with Dr. Spencer that this would force me from the use of the term rock basin to valley erosion. Valley erosion by ice means rock basin formation. The ice erodes, according to my argument, in broad north and south valleys; and when one of these valleys turns to the east or the west, or when it joins an east and west main stream, the marked ice erosion ceases. If, for instance, Cayuga river flowed northward and was tributary to an east and west Canadian stream, the ice erosion deepened the valley of Cayuga but failed to deepen the east-west valley to a great degree; so that the north and south

*The following argument has been communicated to the editor of *The Glacialists' Magazine* in a recent contribution by the writer.

†See Report of Chief of Engineers, U. S. Army, 1882, pp. 2521, 2522, Appendix MM; or Ex. Doc. No. 93, 46th Congress, 3d Session, pp. 7, 8.

valley became *by valley erosion a rock basin.* I should expect, therefore, to find valley erosion north of lake Cayuga as far as the broad preglacial valley extended northward. My conception of rock basin erosion is this, and not local concentration of energy to scoop out a depression.

Cornell University, Ithaca, N. Y., July 30, 1894. RALPH S. TARR.

PERSONAL AND SCIENTIFIC NEWS.

THE SUMMER MEETING OF THE GEOLOGICAL SOCIETY of America was held at Brooklyn, N. Y., August 14 and 15. The attendance numbered thirty-eight. Vice President N. S. Shaler presided, and on opening the sessiou feelingly referred to the great loss to the Society sustained in recent death of its first Vice President, George H. Williams, of Baltimore, and of Amos Bowman, of Anacortes. The Council fixed upon Baltimore as the place for the winter meeting, Dec. 27, 28 and 29. Eleven new fellows were elected. The programme showed twenty-six papers to be read. The following abstracts have been furnished for the AMERICAN GEOLOGIST:

The Nickel Mine at Lancaster Gap, Pa., and the Pyrrhotite Deposit at Anthony's Nose, on the Hudson. J. F. KEMP, New York city. The paper described with maps, sections, lantern views and specimens, these two deposits of nickeliferous pyrrhotite. The former is on the contact between a great intruded lens of some original, basic, intrusive rock that is now altered to a mass of coarsely crystalline, green hornblende (i. e., is an amphibolite) and its walls of mica schist and pegmatite. The latter is a lens or pod, of the type familiar in the iron mines of the highlands of New York and New Jersey, and is in acidic gneiss of the composition of granite. The question of origin was discussed with especial reference to magmatic separation, and with comparisons with nickel ores elsewhere in America and in Norway.

A Connection between the Chemical and Optical Properties of Amphiboles. ALFRED C. LANE, Houghton, Mich. Mr. Lane alluded to the frequent occurrence of zones of different colors and optical properties in uralitic and other amphiboles, the bluer ones probably containing more soda, and showed a diagram which indicated that with the increase in soda the birefraction on the orthopinacoid decreased, becoming 0 for about 6½% of soda and then increasing, but with position of the greater and less axes reversed. He urged the ease and importance of making observations on the orthopinacoid section on all those who have to investigate amphibolites.

On a Basic Rock derived from Granite. C. H. SMYTH, JR., Clinton, N. Y. The paper described a dark colored, massive rock associated with the hematite of the Old Sterling mine in Jefferson county, N. Y. The rock has always been called serpentine, but its origin has been uncertain. Examination in the field and with the microscope shows it to be derived from granite, but greatly altered from its original condition. The character of the changes which the rock has undergone was briefly outlined; and it was suggested that the alteration is due to crushing of the rock by regional disturbances, together with the infiltration of solutions derived from decomposed pyrites.

The process of Segregation as illustrated in the New Jersey Highlands. RALPH S. TARR, Ithaca, N. Y. The various theories offered to account for the New Jersey iron ores were stated and objections pointed out. The process of segregation was then discussed and the banding of some of the New Jersey gneisses and limestones described. An instance of segregation was given, where blue dolomitic limestone has been altered to calcite with bands or impurities, sometimes crystallized, though originally disseminated in minute grains through the dolomite. This process was studied in the slide and the resulting banding was in all respects, except in size, likethe coarse banding of the white limestone. The possible application of this to gneissic banding was then pointed out.

Alunogen and Bauxite of New Mexico, with notes on the geology of the Upper Gila region. WM. P. BLAKE, New Haven, Conn. The deposits of alunogen and bauxite are found in the upper Gila river region, about forty miles from Hanover. At Hanover the rock formations are Paleozoic metamorphic limestones and syenites of greater age, characterized by large deposits of iron and zinc ores. Further north the country is covered with a thick deposit of volcanic sediments and lavas, filling the ancient valleys. The alunogen occurs in these formations and exudes from the cliffs in places where there has apparently been solfataric action by which the rocks have been altered and left without much silica. This may have been removed by hot water and steam, but iron pyrites appears to have been an important factor in the changes and in the production of the alunogen, which is remarkably pure and free from iron. Bauxite is the result of the alteration of the volcanic rock in place and is, like the French bauxite, a residual product and not deposited from solutions.

A study of the cherts of Missouri. By EDMUND OTIS HOVEY, New York city. The paper gave the results of work on some thirty-eight specimens of chert from various localities in the Lower Magnesian and Lower Carboniferous strata of the state. The cherts from the former series are non-fossiliferous, while those from the latter are usually crowded with the remains of crinoids and other calcareous organisms. The cherts vary very much in color, texture and state of preservation. A petrographic discussion occupied a large part of the article. It was shown that the cherts were composed essentially of chalcedony, though quartz and opal are present in some specimens, the latter to a very limited extent in this series. The chalcedony is usually in the form of a granular mosaic (in polarized light), but some of the material is aggregated into concentric spherules showing characteristic negative double refraction. Careful search for sponge spicules was made, but nothing whatever of the kind was found, with one extremely doubtful exception. Five regular siliceous oölites were noted from the Lower Magnesian. A table of eighteen chemical analyses accompanied the paper, in which it was brought out that in cherts not bearing calcareous fossils

The $Si\,O_2$ is usually.................. $>$ 98.00%
" $Al_2\,O_3 + Fe_2\,O_3$ is usually..... $<$ 1.00%
" $Ca\,O + Mg\,O$ is usually.......... $<$ .25%
" $H_2\,O$ (ign) is usually............ $<$ .75%

Determinations on four of the samples showed only comparatively small percentages of $Si\,O_2$ soluble in caustic potash. This fact, together with the small amount of water present and the microscopic characters, shows that very little opal or amorphous silica occurs in these cherts. The author gave a brief resumé of the theories which have been propounded to explain the origin of flint, hornstone and chert, and gave it as his opinion that the Missouri cherts which he studied were due to chemical precipitation from the ocean at the time of the deposition of the strata in which they occur.

Platycnemic Man in New York. WILL H. SHERZER, Ypsilanti, Mich. An account of the discovery in July, 1893, at Canandaigua lake of a well preserved skeleton of this ancient and interesting type of man; showing besides the cranial development of low order, the compression of the femur, the flattening of the tibia and the perforation of the humerus. An explanation was attempted of the presence of these simian characters in early man and their occasional occurrence, especially in negroes, at the present day.

Dislocations in certain portions of the Atlantic Coastal Plain strata and their probable causes. By ARTHUR HOLLICK, Staten Island, N. Y. Indications of faulting, folding, and other forms of dislocation have been mentioned by several observers in the coastal plain region of the southern states, notably by McGee and Dall. In general, however, the observations point to a system of folding or dislocation in a north and south direction, as previous experience in mountain-making principles would cause us to expect for the region.

Further north, extending from Nantucket and Martha's Vineyard through Block island, Gardiner's island, Long Island, Staten island and northern New Jersey, there is another line or area of disturbance having a general east and west direction. It is with this that we have now to deal.—The facts in connection with it are so different from those with which we are familiar elsewhere in America, that but for the circumstance of one portion having been utilized by N. S. Shaler as an example of mountain-making forces, it would not have received consideration by me in such connection. In his report on the geology of Martha's Vineyard, Prof. Shaler argues for the hypothesis of mountain-making forces in order to account for the dislocations of the Cretaceous and Tertiary strata there, and the same views were reiterated in papers read before the Geological Society. Observations made on Long Island and Staten Island forced me to the conclusion that similar dislocations on these islands were to be accounted for on the hypothesis of ice action above, and I subsequently came to the same conclusion for the Martha's Vineyard dislocations, thus following the opinions of both Merrill and Upham.

Further investigations on Long Island and northern New Jersey have greatly strengthened the views previously expressed and we are now in a position to state, as beyond question, that the line of disturbance is coincident with the line of the moraine from Nantucket to northern New Jersey; that the phenomena of dislocation are only to be found where the moraine crossed some portion of the former coastal plain; and that these phenomena cease abruptly where the moraine bends away from or finally leaves the plain.

The phenomena are identical throughout, and any theory advanced to account for them in one portion of the area must also account for them in every other portion. One series of cause and effect has been instrumental throughout, and it merely becomes a question as to which series—ice action or mountain-making forces—is the most probable.

The general type of a section through any part of the region, in a north and south direction, shows a core of contorted Cretaceous and post-Cretaceous sands, gravels and clays, flanked on the north and capped on the top by boulder till, which gradually merges into water-assorted material on the southern flanks and plains beyond.

The Gay Head escarpment is the most extensive section which is anywhere exposed, but a similar structure is seen to exist wherever there is an exposed section through the moraine on Long Island, and if we could imagine that island separated into parts by means of convenient north and south erosion channels Gay Head would be reproduced indefinitely. On Staten Island the moraine crosses a portion of the coastal plain near the Narrows, then bends northward and rests on the Archæan axis and

again enters upon the plain a few miles further west. In that part near the Narrows upon which the moraine rests the underlying strata are folded and tilted exactly as they are on Long Island and Martha's Vineyard. Up to this point the evidences of disturbance are continuous. As soon, however, as the line of the moraine leaves the plain and bends around over the Archæan axis the indications of disturbance cease absolutely and they are not again met with until the moraine once more enters upon the plain.

The dip and strike of the disturbed strata are generally too erratic to be of any stratigraphic value. The prevailing strike, however, follows the general trend of the moraine and the strata are either bent into overthrust folds, tilted with the dip towards the north, or folded into north and south anticlines. East and west dips are also to be seen, especially on the sides of the inlets and harbors of the north shore of Long Island and on Gardiner's Island. These are probably due to the lateral thrust of tongues of ice in advance of the main mass.

The effects produced by the advancing ice front have been wonderfully paralleled by a series of experiments on the compression of plastic strata recently made by Bailey Willis, the results of which are published in the 13th Ann. Rept. U. S. Geol. Survey.

One of the objections to the theory of mountain-making, which appears to be the most serious, is that if the disturbance was preglacial it must have taken place subsequent to the time when the Lafayette or even later formations had been laid down, as we find these gravels included in the distorted strata. This would leave but a very short period of time in which to develop the line of hills upon which the moraine rests, and would imply a sudden disturbance rather than a gradual mountain-making process, and the facts at our command do not warrant the assumption that such conditions prevailed.

Again, any such development of force would inevitably result in the disturbance of strata below as well as upon the surface, and this we do not find to be the case. At Cold Spring the superficial strata are beautifully crumpled and folded, but where the lower strata are exposed these are undisturbed. Finally, in this theory we should have to dismiss as unworthy of serious thought the coincidence of the disturbed strata with the line of the moraine and their absence elsewhere, and to regard this as a coincidence only. [The paper was illustrated by charts and sketches.]

Faults of the region between the Mohawk river and the Adirondack mountains. N. H. DARTON, Washington, D. C. An account of structural relations and general stratigraphy of the Lower Paleozoics in the region extending from the Mohawk valley to the southern edge of the Adirondacks and eastward to lake George. The series of faults are the most salient features and their relations, distribution and extent were described.

Review of our Knowledge of the Geology of the California Coast Ranges. By H. W. FAIRBANKS, Berkeley, California. The Coast ranges were defined geographically and pronounced a mountain system separate from the Klamath mountains and the Sierra Nevada. They are shown to be not a new range, but rather an old one, with an axis along which dislocation has taken place repeatedly from pre-Cretaceous times until post-Tertiary. Their stratigraphy was discussed in detail, and they were shown to be made up of (1) a metamorphic pre-Cretaceous core, ranging in age probably from Carboniferous to late Jurassic; and (2) a later non-metamorphic series, composed of Cretaceous, Tertiary and post-Tertiary rocks. The lithology and structure of the Coast ranges were compared to those of the Sierra Nevada.

Tertiary and early Quaternary Baseleveling in Minnesota, Manitoba, and Northwestward. WARREN UPHAM, Somerville, Mass. The great northwestern plains have an approximately flat surface which has been lowered by Tertiary baseleveling 500 to 3,000 feet below the original surface of the Laramie and Montana strata as they were at the end of the Cretaceous period. Measures of this general erosion are supplied by the Coteau des Prairies, the Turtle mountain, and numerous other isolated hill and mountain areas upon the country reaching thence west to the Rocky mountains.

Near the end of the Tertiary era and in the early Quaternary, the eastern part of this vast baseleveled expanse was deeply eroded and newly baseleveled, the resulting lower plain being the flat area of the Red river valley, averaging 50 miles in width, and of the wider Manitoba lake region. The depth of this later immediately preglacial erosion was 300 to 1,000 feet, as shown by the Pembina mountain and the Manitoba escarpment, which extends thence northward along the west side of the great lakes of Manitoba to the Saskatchewan river. The chief topographic features of Minnesota and Manitoba have been produced by these cycles of baseleveling, especially by the latter which was due to a great uplift of the region terminating in the Glacial period.

Departure of the Ice-sheet from the Laurentian Lakes. WARREN UPHAM, Somerville, Mass. Beaches and deltas observed in the vicinity of Duluth are referred to (1) the Western Superior glacial lake, outflowing southwestward across the divide between the Bois Brulé and St. Croix rivers in northwestern Wisconsin; (2) the glacial lake Warren, outflowing southward by Chicago to the Des Plaines, Illinois, and Mississippi rivers; and (3) the glacial lake Algonquin, outflowing by the St. Clair and Detroit rivers, and along the bed of lake Erie, to the incipient Niagara river and glacial lake Iroquois. The extent of high stages of lake Warren, shown by beaches around lake Superior and eastward to lake Nipissing and to the east end of lake Erie, traced and mapped by Taylor, Gilbert, Spencer and others, implies that the ice-sheet had retreated from the northern border of the United States as far eastward as to the angle of the drift boundary near Salamanca in southwestern New York, while yet the great lobe of this ice-sheet east of Salamanca remained upon New York, northeastern Pennsylvania, northern New Jersey, and New England. This unexpected view of the order of recession of the ice-sheet is found explainable by the meteorologic conditions of abundant snowfall at the east brought by storms saturated from the melting ice surface at the west. The paper also traced the history of the Niagara river, which is thought to afford a measure of the Postglacial period as about 7,000 years, and called attention to the expansion of lake Iroquois northward and northeastward until its waning ice-barrier was finally melted away from the St. Lawrence valley near Quebec, then admitting the sea to the St. Lawrence, Champlain, and Ottawa valleys.

The Extension of Uniformitarianism to Deformation. By W J MCGEE, Washington, D. C. Many shores, like that of Holland, are subsiding at a considerable rate; yet no horizontal movement accompanies the subsidence. Many coasts, like that of Scandinavia, are skirted by elevated beaches indicating recent emergence; yet there is nothing to indicate and everything to disprove coincident lateral movement. Many districts, like that of the Laurentian lakes, are traversed by ancient strands, proving not only vertical movement but decided warping in the earth's crust; yet no record of accompanying horizontal movement is found. The coastal zones of the continents are made up of series of formations and unconformities recording wide vertical oscillation of the land with respect to the sea; yet little evidence of horizontal movement has been detected. About one-fourth of the land of the earth is moun-

tainous and the rocks are deformed therein—this is the aberrent fraction of the earthcrust: about three-fourths of the land area is non-mountainous, the rocks not deformed—this is the normal portion of the earthcrust; and throughout the normal continents, as throughout the coastal zones, there is a succession of formations and unconformities recording profound vertical oscillation, with no concurrent horizontal movement save that of extension in normal faulting. So, excluding the mountain regions in which the rocks are crumpled, it may be affirmed that the prevailing movements of the earthcrust are essentially radial, only subordinately tangential. In the beginning of geology attention was confined to the rare and the remote among phenomena, to the analogic only in reasoning; in that branch of geology dealing with particle movement attention has long been given to the common and the near and the reasoning has risen to the plane of homologizing processes, and uniformitarianism has resulted; but in the geology of corporeal earth movement inference is still based on the abnormal, reasoning is still analogic; and thus the current philosophy remains on the borderland of science. A strong plea was made for study of the known vertical movements of the earthcrust and for reasoning from the known to the unknown by direct homology.

Trias and Jura of Shasta county, California. By JAMES PERRIN SMITH, Stanford University, California. The columnar section of the metamorphic series of the Klamath mountains was given; this is made up of strata from Devonian to Jurassic age. The presence of Middle Trias was shown by fossils. This is overlain conformably by slates and limestones with a rich fauna of Upper Triassic age, directly comparable to that of the zone of *Tropetes subbullatus* and *Trachyceras aon* of the Karnic in the Tyrolean Alps. This fauna is shown, by its affinities to Himalayan and Alpine species, to belong to a prolongation of the Mediterranean and Indian Triassic provinces, and not to the Arctic-Pacific province. The occurrence of Jurassic fossils was mentioned and new localities given. The widespread Jura-Cretaceous unconformity in the Coast Range, the Klamath mountains, and the Sierra Nevada, was considered a proof that these three ranges belong to one great mountain system in which the disturbances were closely associated.

Restoration of the Antillean continent. By J. W. SPENCER. There has been a general impression that the Antilles were at some time connected with one or both of the American continents, which extension some thought could not have obtained. This is the first study in which definite evidence of such connection has been proved, and also the date of the connections. The investigation is the outgrowth of enquiry into the changes of level which the continent has undergone, but now greatly advanced, both in detailed proofs and in the philosophical inductions. The geomorphy of land valleys, both of mountain regions and across plains, is investigated with the conclusion that all the valleys with gradual descent and enlargement are the products of atmospheric erosion, where the same are kept open by drains. The land surfaces are deformed by terrestrial undulations of unequal degree, but not such as to obliterate the drainage features; yet these epeirogenic movements may produce transverse barriers which turn the valleys into lake or sea basins, or which may be further deformed by orogenic movements. The submarine shelves bounding the continent and portions of the West Indian shores were described, as also the fjords which traverse them for hundreds of miles in length, with depths of more than two miles, continuing to the margin of the continental plateaus and floors of the Antillean seas. These fjords all connect with modern or buried land valleys, which are now silted up to from 200 to more than 900 feet. The structures of the drowned valleys and those of the land valleys are in every respect identical, and the conclusion is that the continent was as

much higher than now as is the measure of the greatest depths of the submerged cañons, less some considerable correction for exaggerated coastal deformation, the maximum amount of which in many cases can be determined. Accordingly the southern states and the West India islands formerly stood from 8,000 to 12,000 feet higher than now, with the floor of the gulf of Mexico and the Caribbean sea low plains extending and draining to the Pacific ocean. The first Antillean continent, deeply sculptured by erosion, existed in the earlier and middle Pliocene period, followed by a subsidence, so that the West Indies were reduced to a few small islets, and the sea encroached upon the continent to the extent of 250,000 square miles. Again, there was another continental bridge betwen the two Americas during the first half of the Pleistocene period, after which time the continent was lost, and marine Pleistocene formations were accumulated, followed by terrace epochs and several minor oscillations. The Pacific ocean was cut off from the Mediterranean waters for the last time in the Pleistocene period, when the Atlantic currents were admitted.

The physical phenomena set forth in this long paper were supported by the biological, both of land and of water, and again they react so as to explain the distribution and extinction of life. The geological bearings of this paper are far reaching. Not only do they show the mobility of the earth's crust so that quiet but enormous changes of level, ranging vertically through two miles and a half both ways, have taken place in recent times, but they may lead to the discovery of a real Atlantis. In the north they will have a bearing upon the glacial features, and involve fundamental conditions not yet considered. So, too, in the distribution of animals, we should find much light from the extension of the studies already begun in this paper.

Other papers presented before the Society at this meeting, several of them being read by title in the absence of the authors, are as follows:

The drumlinoid hills near Cayuga, N. Y. RALPH S. TARR. A description of some of the parallel drift hills south of lake Ontario, with some inferences concerning their origin. The evidence points toward origin by a process of glacial erosion acting upon a preëxisting sheet of till.

Drumlins in the vicinity of Geneva, N. Y. D. F. LINCOLN.

Channels on drumlins, caused by erosion of glacial streams. GEORGE H. BARTON. (This paper, presented last winter before the Society by title only on account of lack of time at the last session, was read at this meeting. An abstract of it appeared in the AM. GEOLOGIST for last March.)

Cenozoic history of a portion of the middle Atlantic slope. N. H. DARTON.

Use of the aneroid barometer in geological surveying. CHARLES W. ROLFE.

Oil and Gas in Kansas. ERASMUS HAWORTH.

Evidences as to the change of sea-level. N. S. SHALER.

The geological history of Missouri. ARTHUR WINSLOW.

The Magnesian series of the Northwestern States. C. W. HALL and F. W. SARDESON.

The Stratigraphy of the St. Louis and Warsaw formations in southeastern Iowa. CHARLES H. GORDON.

The Permo-Carboniferous and Permian rocks of Kansas. CHARLES S. PROSSER.

The Trias and Jura of Shasta county, California. JAMES PERRIN SMITH.

The American Association for the Advancement of Science, holding its meeting under the presidency of Dr. Daniel G. Brinton, in Brooklyn, N. Y., August 15th to the 22d, had an attendance of 477 members and associates; and 213 new members were elected. In Section E (Geology and Geography) the address of the vice president, Prof. Samuel Calvin, was on "The Niobrara Chalk," as presented in the foregoing pages. A list of the papers read before this section is as follows, with brief notes or abstracts which have been received for some of them. It is expected that several of the papers will be given in full in our future numbers.

Water resources of the United States. J. W. Powell. The ultimate development of the vast arid and subhumid regions in the western half of the United States was shown to depend on the thorough utilization of the water resources for irrigation. A large part of the work of the United States Geological Survey, under the author's direction, has been given to investigations of the amount of available water supplies in these regions, and to the extent of their fluctuation, by which their value for agriculture is determined.

The National Domain. F. H. Newell.

Geographical development of China, Korea, and Japan. Gardiner G. Hubbard.

A miniature extinct volcano. W J McGee.

A Paleozoic eruption in Missouri. Arthur Winslow.

The Zinc mines at Franklin Furnace and Ogdensburg, N. J. J. F. Kemp. The history of the mines was first sketched, with notes of their chief ores and minerals. The general geological questions involved in the region followed, and the problems of the blue and white limestones and of the intruded granites were considered. The ore bodies were then described by means of maps and sketches. The Ogdensburg one was shown to be a steeply pitching syncline: and the Franklin Furnace one, a low pitching syncline with a collapsed anticline on the eastern limb. The ore bodies were not regarded as having ever been continuous, but rather as each a local deposit along nearly the same geological horizon. The unique geological and mineralogical character of the deposits was commented on, with references to somewhat similar deposits elsewhere. A list of the minerals of these localities, sixty-five in all, was written on the blackboard: a series of specimens, illustrative of the paper, was exhibited; and hints were given regarding the proposed excursion to these mines.

Notes on the Atlantic Miocene. W. H. Dall. An examination of the invertebrate fossils of the strata at Gay Head, Martha's Vineyard, heretofore regarded as Miocene, confirms their Miocene age and allows them to be referred to the Upper Chesapeake formation, between the St. Mary's and Yorktown horizons. A list of the species was included and two new forms described. Another horizon, unconformable with both the Miocene below and the glacial drift above, afforded a few molluscan remains which indicate a Pliocene age for this bed.

The phosphatic rock of the Ashley river region, near Charleston, S. C., is found to be of upper Miocene age. It has previously been called Eocene or Postpliocene. The phosphatization may have been in Pliocene times or the late Miocene. This rock contains no Eocene types; and it was shown that the Eocene age of the associated Ashley river marl bed rests upon very unsatisfactory evidence. It may also prove to be Miocene.

A new fossil Liriodendron from the Laramie at Walsenberg, Colo., and its significance. ARTHUR HOLLICK. This new species of *Liriodendron* was found while overhauling a quantity of material which was sent to the late Prof. J. S. Newberry by Mr. R. C. Hills. It was never described, but a manuscript name was attached which will be retained when the description is prepared. The most striking feature is the wing-like appendages to the petiole of the leaf. Appendages of a somewhat similar character are known in other genera, and we are indebted to Prof. L. F. Ward for having worked out their apparent significance in the case of *Platanus* (Proc. U. S. Nat. Museum, vol. XI, 1888, pp. 39-42). The evolution of the genus *Liriodendron* is also an exceedingly instructive study, which has been ably presented by Newberry (Bulletin Torr. Bot. Club, vol, XIV, 1887, pp. 1-7, with two plates). The new material enables us now to consider this genus in the same light as that in which *Platanus* was considered, namely, that these appendages may represent basilar expansions of the leaf blade which separate and finally become merely stipular appendages at the base of the petiole. (The paper was illustrated with drawings of fossil forms of *Liriodendron* and *Platanus*, and with dried specimens of *L. tulipifera* and *P. occidentalis*.)

The age of the Galena limestone. N. H. WINCHELL. This paper was based on extended paleontological studies carried on by the Minnesota survey recently, which show that the Galena limestone is essentially of the age of the Trenton limestone, instead of Hudson River or Utica. It was accompanied by tables showing the relative prevalence of various fossils in the several parts of the Lower Silurian concerned.

The Carboniferous strata of Shasta county, California. JAMES PERRIN SMITH. The general structure of a portion of the Klamath mountains was briefly discussed and the systems of faults and folds indicated. The oldest strata of the region are of Devonian age, overlain by the Baird shales, which belong to the Lower Carboniferous. The latter have a fauna analogous to that of the Eureka district of Nevada, and thus have many Devonian species commingled with the Carboniferous. Faunally they are thought to be homotaxial with the Waverly, but stratigraphically they belong higher in the section. Above the Baird shales lie about 2,000 feet of limestone with a Carboniferous fauna probably equivalent to the Coal Measures. Above the limestone are calcareous shales, with a fauna equivalent to that of the Robinson beds of Plumas county and thus probably of Permo-Carboniferous age.

The later geological changes in Cuba. J. W. SPENCER. (See the foregoing abstract of Dr. Spencer's paper before the Geological Society.)

Quaternary time divisible in three periods, the Lafayette, Glacial, and Recent. WARREN UPHAM. The Quaternary era is thought to have included a long time of preglacial uplift of the areas which became ice-covered, as indicated by the deposition and erosion of the Lafayette formation. The Lafayette period was followed, at the time of culmination of its continental elevation, by the Ice age or Glacial period, whose geologically short closing stage, induced by the sinking of the ice-loaded lands somewhat below their present level, has been named the Champlain epoch. The ensuing Recent period, extending to the present day, is learned by numerous independent means of estimate to have comprised some 6,000 to 10,000 years; and the ratio of the duration of the three Quaternary periods is estimated to be approximately as 10:3:1, giving for this entire era probably about 100,000 years.

The Columbia formation in northwestern Illinois. OSCAR H. HERSHEY. The Florence gravel, Valley loess, and Upland loess, successively deposited in the valley and drainage basin of the Pecatonica river, are shown to be equivalent with the Columbia formation of the lower Mississippi

valley. The loess was deposited apparently long after the earliest sheet of the glacial drift, but it is bordered eastward by a later drift sheet with which it seems to have been contemporaneous. The Columbia and loess deposits therefore are thought to represent a somewhat late stage of the Glacial period.

Progress in the geological survey of the Great lakes. J. W. SPENCER. The great lakes tributary to the St. Lawrence river are ascribed to differential movements of subsidence and elevation during the Pleistocene period, whereby portions of preglacial river valleys have been transformed into lake basins. Previous to that period the upper Ohio, the Allegheny, and other rivers of northwestern Pennsylvania, flowed northward to what is now the bed of lake Erie; from the southern part of the area of lake Michigan a river flowed east across the lower peninsula of Michigan to lake Huron; and drainage from the Georgian bay area passed eastward to lake Ontario, whose bed was a part of the upper course of the preglacial St. Lawrence.

Duration of Niagara falls. J. W. SPENCER. During the earlier and longer part of the history of the Niagara river, it is thought to have received only the outflow of the Erie basin, the three upper lakes meanwhile outflowing by the way of lake Nipissing and the Ottawa river. Computations from the changing conditions of the Laurentian lakes indicate about 32,000 years as the time which has been occupied in the erosion of the gorge below the falls.

Drainage of the Great lakes into the Mississippi river by way of Chicago. J. W. SPENCER.

On standard sizes for trays, drawers, and cases for mineralogical and microscopical cabinets. W. G. LEVISON and D. S. MARTIN.

A prehistoric relic, with extracts from a survey of lands in Monroe and Ontario counties, N. Y., which were under the ancient lake of Ontario. C. H. JENNER.

Exhibition of a microscope made of aluminum for portability, and modified in construction to adapt it for searching over the surface for large mineral specimens. WALLACE G. LEVISON.

Exhibition of map and photograph of a peat bed in Prospect Park, Brooklyn, N. Y., made in 1867, when the peat was removed and the excavation filled. WALLACE G. LEVISON.

The geological atlas folios issued by the U. S. Geological Survey. F. H. NEWELL.

The minerals of Paterson, Upper Montclair, and the Palisades, N. J. JOSEPH H. HUNT. An interesting collection of these minerals was exhibited by the local committee.

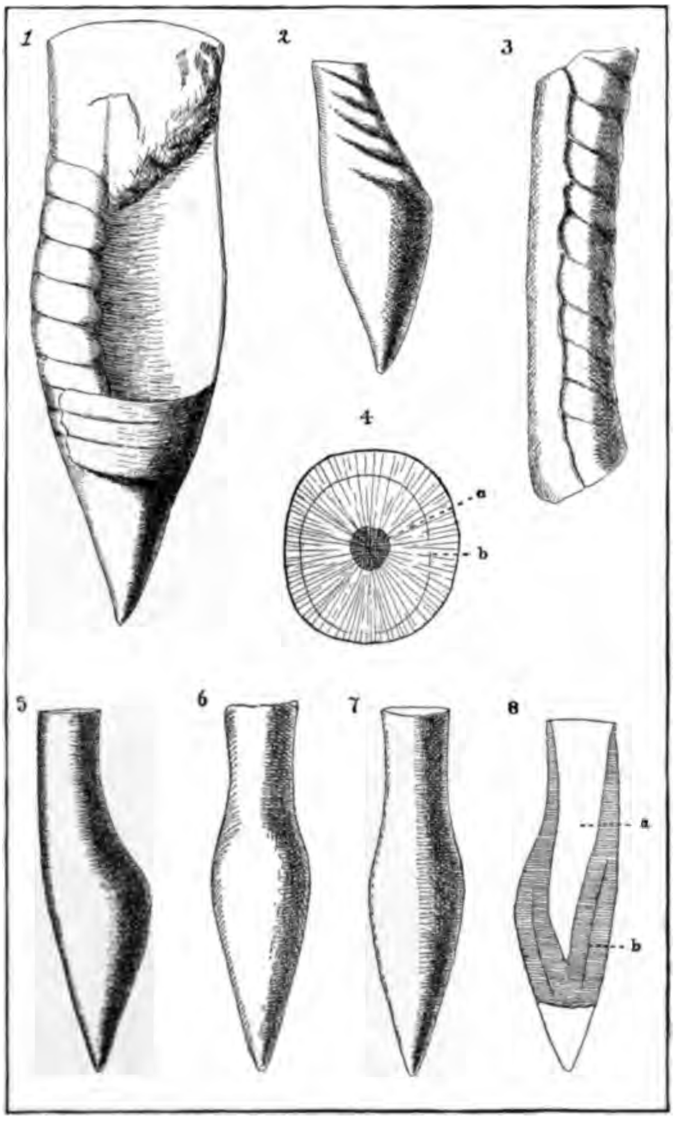
On the age of the St. Clair limestone of Arkansas. S. H. WILLIAMS.

The report on progress in Geology from the Centennial to the Columbian expositions. JED. HOTCHKISS.

Oil and Gas in Kansas. ERASMUS HAWORTH.

Some alteration phases in the granitic rocks of the Northwestern States. C. W. HALL.

San Francisco was chosen as the place of meeting of the Association next year, for which Prof. Edward W. Morley, of Cleveland, Ohio, was elected president. The officers of Section E, elected for that meeting, are Maj. Jed. Hotchkiss, of Staunton, Va., vice president, and Prof. J. Perrin Smith, of Palo Alto, Cal., secretary.



NANNO, A NEW CEPHALOPODAN TYPE.

THE

AMERICAN GEOLOGIST.

VOL. XIV. OCTOBER, 1894. No. 4.

NANNO, A NEW CEPHALOPODAN TYPE.*

By J. M. CLARKE, Albany, N. Y.

(Plate VI.)

The material representing this remarkable type of cephalopod structure was collected by Messrs. E. O. Ulrich, Charles Schuchert, and the late W. H. Scofield from various localities in the Trenton series of Minnesota. The novel character of the fossils was recognized and closely studied by the first two of these gentlemen. When, therefore, the specimens were placed in my hands for description I was able to avail myself of these previous observations, especially those by Mr. Schuchert.

The usual aspect assumed by these bodies is somewhat that of a small *Belemnites*. The apical and posterior portion has a rounded and evenly tapering surface which would give it the form of a true cone, were not one side, when the body is viewed laterally, quite oblique, while the other is nearly vertical. Thus viewed the shells are asymmetrical laterally, but as seen from the dorsal and ventral side they are bisymmetrical. After the conical expansion has continued for about, or less than, one-half the length of the body, there is a rather abrupt contraction on the oblique side and the shell becomes

*Published with the consent of the State Geologist of Minnesota.

much smaller and more circular in cross-section. Thus toward the upper extremity of the shell a cylindrical tube is formed. Upòn comparing the bodies as thus described with the single specimen which represents more nearly the structure of the entire shell, it appears that the orientation above assumed is not strictly correct. The normal position of the conical posterior portion is such that the straight and the oblique side converge at nearly the same angle to the vertical axis; this diverts the cylindrical or upper portion of the body to one side.

These peculiar bodies are siphones; those represented on plate VI, figs. 2 and 3, show the oblique impressions left by the septa upon the surface of the cylindrical portion, and fig. 1 affords a conception of the relation of these siphones to the septate part of the shell. In the latter is seen the central and symmetrical position of the apical cone with reference to the entire shell, its abrupt contraction and the deflection of the cylindrical part of the sipho to one side. At the point where the contraction of the sipho begins, its diameter is that of the shell, and from the apex to this point there is no trace of septa. With the appearance of the septa begins the contraction of the sipho. That the septa did not completely encircle the sipho is shown by several of the specimens which present a smooth surface on the dorsal or outer side, the marks of the septa being there interrupted (figs. 2, 3). One of the specimens has the thin wall of the conch adhering to the siphonal wall along this surface.

Upon examination of the internal structure of these siphones they are found to be completely solid in the apical portion for usually about one-half the length of the præseptal cone, but in some examples this solidification extends for the entire length of the cone and into the cylindrical part of the tube. The cavity of the sipho above this filling is a narrowly conical chamber whose walls gradually become thinner from the apex upward, their upper edge appearing to be rounded off and finished.

The substance of the siphonal cone and walls is invariably very compact, radially crystalline calcite, indicating, inasmuch as all the specimens have been found in calcareous shales and clayey limestones, a simple modification of the

original organic deposit; the internal cavity is filled with the mud of the sediment. Cross-sections of the cone in both directions indicate that this is not a simple body, but is composed of at least two invaginated and consolidated sheaths, the line between which is represented only by a faint streak or difference in the texture. This evidence, though obscure, is indisputable that the sipho enclosed or was composed of siphonal sheaths, as in *Piloceras*, *Vaginoceras* and *Endoceras*. The sections afford no evidence of an endosiphon or tube connecting the apices of these sheaths.

The addition of the septate portion of the shell gives the species a fusiform and symmetrical appearance, broadest below the aperture, the sipho seeming to extend nearly, if not quite, the entire length of the shell. The septa are gently and regularly concave over most of their surface, but abruptly deflected immediately about the sipho. There were apparently about twelve in the length of the shell as preserved. The first septum seems not to conform to the contracted surface of the cone, which has a much greater obliquity, and there thus appears to be an irregular wedge-shaped cavity between these two surfaces, but there is no evidence whatsoever that the conical end of the sipho was in any way involved in this cavity except at its upper surface.

The apical solid cone was unquestionably external, except so far as ensheathed by a mere coating or film of the shell-tube.

All the specimens indicate that these shells were of small size; a nearly complete sipho has a length of 36 mm.; its greatest width is at 19 mm. from the apex and measures 10 mm. in major, and 8.5 mm. in minor axis; its apertural diameters are 8 and 6 mm. Another and more splendid specimen measures 40 mm. in length and is broken at the aperture. Here the length of the apical cone is 22 mm. The most complete example has a length of 58 mm.; the apical cone measures 15 mm.; the entire diameter of the shell is 18 mm. at its widest part and 16 mm. at or near the aperture.

The shells thus described represent but one species, which it is proposed to term *Nanno aulema*. From their structure it is evident that their relations are closest to *Piloceras*, but

with noteworthy differences. The initial parts of the shell of *Piloceras* are still undescribed, but we may assume that were it possessed of such a solid apical sipho as is *Nanno*, that would be the part most readily preserved, as in this case. The sheathing of the sipho, its great size and its relation to the septa are structural points allying these two genera. The presence of the apical siphonal cone may indicate the existence of *Nanno* for a considerable period in the young state simply as an aseptate body, and with such evidence the genus would seem to be a degree more elemental than our present knowledge ascribes to *Piloceras*, inasmuch as the septate condition in the latter genus is of earlier occurrence. It may be suggested that the solidification of the præseptal cone is to some extent due to such secondary causes as have produced the solid guard in *Belemnites*. The appearance of these siphones and the crystalline structure of their substance strongly suggests that genus, even though there is little superficial similarity in the relations of these parts to the septate portions of the shell in the two genera.

Geological horizon. The material studied consists of seven specimens obtained from the Trenton shales of Minneapolis and from the Galena shales at Chatfield, Minnesota.

EXPLANATION OF PLATE VI.

Nanno aulema.

FIG. 1. The most complete example observed; showing the form of the entire shell, the apical cone, position of sipho and some of the septa. × 1.3.

FIG. 2. The præseptal cone with a portion of the annulated siphonal tube; a lateral view. × 1.3.

FIG. 3. A fragment of a sipho, showing only the cylindrical portion to which a part of the smooth external shell adheres. × 1.3.

FIG. 4. A cross-section of the apical cone; showing at *a* the filling of the internal cavity, at *b* the line of subdivision of the sipho into siphonal sheaths. The radial structure of the substance of the body is also indicated. × 2.6.

FIG. 5. Lateral view of a sipho as usually found, with smooth cone and cylinder. ×1.3.

FIGS. 6 and 7. Ventral (anti-siphonal) and dorsal (siphonal) aspects of the same specimen.

FIG. 8. A vertical longitudinal section of a sipho, showing at *a* the form of the internal cavity, and at *b* the line of division between the sheaths. × 1.3.

THE RELATION BETWEEN BASELEVELING AND ORGANIC EVOLUTION.*

By. J. B. WOODWORTH, Cambridge, Mass.

CONTENTS.

INTRODUCTION.

The considerations here presented have grown out of the studies of river history and denudation which form the newly developed branch of geology known as geomorphy, geomorphology, or simply physical geography. It is one of the tenets of this school of geologists that certain plains of denudation now traceable over wide areas have resulted from subaërial erosion. Not a few geologists, however, still maintain the view of marine erosion which Ramsay was the first to advocate regarding these ancient, tilted and now generally

*An address read before the Harvard Natural History Society at its April meeting, 1894. The paper in its present form has been partly rewritten, but it still retains a strain of the lecture style in which it was conceived. It is published with the view of promoting inquiry into this subject, with which it deals in a preliminary and necessarily superficial manner.

deeply dissected plains. The contrast between the old and the new views when carried to their consequences in the organic realm is so striking that it is thought the following discussion will be acceptable both to those who do and to those who do not grant the competency or opportunity of meteoric denudation to account for these baseleveled areas or *peneplains*.

SYNOPSIS.

The object of the paper is to discuss the effect, on organisms, of the changes in physical geography which arise in the process of baseleveling. Part I presents a cursory review of the history of opinion regarding land erosion, including the speculations of some ancient writers. Part II deals with the general effects of river changes on organisms, and aims to set forth the manner in which these changes have influenced the dispersion of freshwater species. Part III has to do with the Jura-Cretaceous peneplain of North America in particular, with the determination of the time of development of the peneplain, and with the development of the fauna and flora of the Mesozoic era which lived upon its surface. It is inferred that the production of this lowland was favorable to the reptilian class, and that it was a factor in securing to them the dominance which they enjoyed even after the mammalia had made their appearance. In conclusion, baseleveled lands or peneplains and the periods of their elaboration are compared with glacial epochs and marine invasion in their effect as the environment of organic life.

PART I. HISTORICAL SKETCH.

In reviewing the rapid strides which the new school of topographic geologists have made in interpreting the history of erosion alone, we are in danger of overlooking the fact that the idea of a land reduced to an essential plain by erosion is far older than anything like a demonstration of the existence of a surface of this nature. In a work entitled, "The Scripture Theory of the Earth,"* published in London in 1773, the anonymous author, after instancing numerous cases of the fall of mountains, erosion by snowslides, ice, rains and rivers, presents the following conclusion:

*The full title reads: "The Scripture Theory of the Earth throughout all its revolutions and all periods of its existence, from the Creation to the final Renovation of all things." See pp. 365-6.

From these observations we are led to conclude that it is possible, if not probable, that, in a course of ages, the mountains and vallies may be brought nearer to an equality with each other; there being, from the co-operation of so many causes, a tendency in nature to this end, without anything to oppose or counteract it. The only objection that occurs to me is that, in this case, it may be thought the earth would be in danger of being overflown by the sea: And the possibility of this consequence hath been alledged. But there is no such dead level of the earth supposed, that there would not be eminences and inequalities enough left to keep out the return of the sea.

In this quotation we find the essential features of two characteristics of the Jura-Cretaceous peneplain as it occurs in North America,—the nearly level surface of the time, and the eminences or monadnocks which had resisted with partial success the denuding forces. This same writer continued his disquisition upon this subject, "supplying as little as possible from reason, or hypothesis,"* in the fashion of the Mosaic writers of his time, tracing to Plutarch† the records of a tradition, "that the time would come, decreed by fate, when the earth would be reduced to an even plain, and mankind should all live under one happy policy, and be all of one language." The poet Prior, quoted by the same writer,‡ conceived of the leveling of lands and building up of the correlated plain, when he says:

> Disparted streams shall from their channels fly;
> And deep surcharg'd by sandy mountains lie,
> Obscurely sepulchred. By eating rain,
> And furious winds, down to the distant plain,
> The hill that hides his head above the skies,
> Shall fall. The plain by slow degrees shall rise
> Higher than erst had stood the summit-hill:
> For time must nature's great behests fulfill.

Views of the British School.

The first recognition of baseleveled lands is due to the work of Sir A. C. Ramsay in Wales, and it was there he formulated the conception of their origin by marine erosion. In his terminology, they are "plains of marine denudation," marking great unconformities in the older strata, or giving rise to the even-topped hills of the existing surface. Surrounded on all sides by the tidal waters of an active sea, in a region where the

*Ibid. Introduction, p. 12.
†In Iside.
‡Prior's Solomon, Book I.

existing rivers are relatively insignificant or impoverished examples of their kind, the British geologists early found in their environment an easily comprehended incentive to ascribe the shape of the land to the action of the sea. Although this inference was a consequence of the insular position of the British school, we find among its founders, in Hutton and Playfair, a keener sense of the efficiency of rivers than appears to have been enjoyed by our later great teacher, Lyell.

It may be permissible in this connection to present the remarkable diversity of forms claimed for this agency by Jukes, who stands as an extremist of this school. Jukes's views, it must be said, accord pardonably with his opportunities for geological observation, since his lot was cast first in Ireland and then in Newfoundland, two insular fields ill calculated to inculcate those comprehensive ideas regarding the interaction of existing and now locally inoperative causes which it is the privilege of the wider ranging continental geologist to recognize, with the assignment of its due importance to each in the economy of geological work. It was partly owing to this circumstance and partly perhaps to the influence of the thought of his contemporaries, that Jukes wrote as he did:

> But when we feel ourselves entitled to take for granted that all cliffs at the foot of which the sea is now beating have been produced by the erosive action of the waves, it only requires us to admit that the land may have stood formerly at lower levels, so as to allow the sea to flow over the lower parts of it, for us to see the probability that all inland cliffs, crags, precipices, valleys and mountain passes, may have been produced in the same way. . . . . And speaking generally, the principal features in the forms of the ground in all lands have been produced by this widespread action.*

The same author states dogmatically, as late as 1862: "Rivers form their own beds, but not their own valleys."† These quotations are directly opposed to the views of to-day, as they are to the earlier and clearer understanding of the competency of rivers shown in Playfair's "Illustrations of the Huttonian Theory." The studies of continental geologists within the past two or three decades have done much to revise opinion upon this subject. Indeed, the work of reconstructing the marine theory of baseleveled lands was begun by Ram-

*T. B. Jukes, The Student's Manual of Geology, second ed., Edinburgh, 1862, p. 101.

†Op. cit., p. 105.

say himself, in his contribution to our knowledge of the work of meteoric agents in England. This awakening of the English school in regard to the work of rivers has gone on until now the reduction of lands to baselevel by meteoric agents is almost admitted.*

Views of the American School.

Powell, Gilbert, Davis, McGee, and others, have established much in the history of the larger rivers of America. As a result of these studies, it is held that rivers and their valleys pass through a cycle of existence, ranging from youth in a country newly elevated above the sea as a plain or mountain belt, through adolescence, maturity, and so on into old age, when, if the land remain tolerably stable, the country will be flattened down into a plain of subaërial erosion, or a *peneplain*. Renovation of the land by uplift, and the consequent revival of stream work, will introduce a new cycle. From the point of view of organic life, which it is proposed to exploit in this paper, the complete cycle may be assumed to begin and to end in uplands of sufficient relief to be characterized as a mountainous habitat, although the first topography may be constructional and the last wholly subsequent and polygenetic, the peneplain occupying the middle and culminating part in this series of progressive geographical changes.

It has been shown by these river studies that in the reduction of a region, either partially or completely, to baselevel, mutual adjustments of streams take place, whereby considerable changes in course and direction are brought about. Systems are dismembered, the headwaters of one being captured and diverted into another through the shifting of divides. By changes in level, some streams have been reversed. In some cases, an axis of uplift has developed across the path of a master river, but the uplift has gone forward so slowly and regularly that the stream has been able to maintain its course across the completed mountain chain. In other instances, changes in the relations of streams have arisen from the process of alluviation in the lower course of a river. It remains now to treat of the bearing of these streams on the dispersion

*Consult Sir Arch. Geikie's Text-Book of Geology, third ed., 1893, pp. 466-470; The Scenery of Scotland, second ed. Also see H. B. Woodward's Geology of England and Wales, first ed., 1876, ch. XIII.

of freshwater mollusks and fishes, these groups being taken for the reason that they record the clearest dependence on river history in their distribution.

PART II. THE GENERAL EFFECT OF RIVER CHANGES ON FLUVIAL FAUNAS.

It has been shown that fishes and mollusks are dispersed by a number of means, some of which, unless actually observed, offer to the investigator no evidence whereby they may be detected in after times. On the contrary, river changes, the topographic effects of which are still retained in the features of a country, afford, when studied in connection with the distribution of its fishes and mollusks, a set of phenomena which it seems likely will at least in some instances prove instructive.

It has been customary to explain the phenomena of distribution in some of the following ways. Günther,* noting that some freshwater fishes are able to migrate into salt water, supposes that the passage from one river to another may have been accomplished in this manner, or that there may have been a temporary passage opened across a watershed by a flood. Lyell† quotes Gmelin as authority for the statement that freshwater fish-spawn are distributed by anseres; and he states further that scattered lakes are stocked by minute eggs, entangled in the feathers of the waterfowl, and that the water beetles (Dycticidæ), which are amphibious and fly in the evening, may transport minute ova to distant pools, as when the fry of fish appear in rainpools. Darwin writes on this subject as follows:

On the same continent freshwater fish often range widely, and as if capriciously; for in two adjoining river systems some of the species may be the same and some wholly different. It is probable that they are occasionally transported by what may be called accidental means. Thus fishes still alive are not very rarely dropped at distant points by whirlwinds; and it is known that the ova retain their vitality for a considerable time after removal from the water. Their dispersal may, however, be mainly attributed to changes in the level of the land within the recent period, causing rivers to flow into each other. Instances also could be given of this having occurred during floods, without any change of level. The wide difference of the fish on the opposite sides of

*An Introduction to the Study of Fishes, Edinburgh, 1880, pp. 211, 212.

†Principles of Geology, eleventh Am. ed., II, p. 374.

most mountain ranges which are continuous, and which consequently must from an early period have completely prevented the inosculation of the river systems on the two sides, leads to the same conclusion.*

Through headwater diversion.

Darwin had in mind evidently those changes whieh a careful study of rivers has established as a part of their history. It is unnecessary here to refer to particular instances† in which by changes in the headwaters of a river, some portion of its drainage has been diverted into another system, carrying with it of course a representatiou of its fauna and a change of condition in the whole life of both streams. It has been further shown that, at successive times, the headwaters of a river system have been diverted into a contiguous basin, so that, since the changes are slow and gradually accomplished, each new capture may introduce into the fauna of a river basin new varieties, which would find themselves in close contest with allied species already introduced, as well as with the older species peculiar to the river system. Dispersal may in this manner be accomplished across a main summit of land, such as that now dividing the waters of the Mississippi basin from those of the Atlantic slope, or it may be limited to interchanges of fauna between parallel streams occupying the same continental slope.

Through antecedent streams.

The not altogether acceptable case of the Green river, which flows through the Wahsatch range in Utah, may be taken as an example of rivers of this class, where the uplift of a mountain barrier has been successfully resisted by the river. So long as unsurmountable rapids or falls do not intervene, there is a free communication across the range. Even where falls of considerable magnitude occur, certain fishes have acquired the habit of leaping them in their attempt to reach the headwaters during the spawning season. If, at a late date in the history of an antecedent river, its headwaters be tapped and led to the sea in another direction,

*Origin of Species, sixth (Am.) ed., New York, p. 344.

†W. M. Davis: A River Pirate, Science, XII, 1889, p. 108.
R. DeC. Ward: Another River Pirate, Science, XIX, 1891, p. 7.
H. L. Harris: A new instance of stream capture, Science, XXII, 1893, pp. 36, 37.
Collier Cobb: A recapture from a River Pirate, Science, XXII, 1893, p. 195.

abandoning the pass through the range, we may have presented the phenomenon of two streams in headwater opposition with identical species; but the "wind gap" will remain as a monument of the time when the streams were part of the same system.

Through alluviation.

Changes of less significance, but often throwing light on the dispersion and consequent modification of fluviatile life, occur in the deltas and alluvial plains of river basins. By increasing alluviation in the delta region, the tributaries of the main stream are often forced aside to flow in the lower, back levels of the plain, along which they may find their way to the sea many miles distant from the vagarious mouth of the master river. In this manner a fauna once common to the main stream and its tributary may be divided except for the occasional communication established by floods in the delta district. But if the separation thus initiated be continued by favorable geological conditions, the isolation of the two faunas may be so complete that any subsequent intermigration between the two river systems must take place through the salt water along the coast, or by one of the interstream changes already described. The Red river of Louisiana is now in this initiatory stage of separation from the Mississippi river.

Through slight submergence.

Where submergence takes place, the lower courses of rivers become converted into arms of the sea. Drowned river valleys of this origin now abound in the northern hemisphere. Where this has occurred the freshwater fauna common to the master stream and its lower tributaries may be cut off from each other by the invasion of salt water, as in the case of those rivers which discharge into the present Chesapeake bay.

Through elevation and revival of streams.

Opposed to the preceding action on organic life, is the uplift of a region like Hudson's bay, whereby the streams would be made to continue their courses seaward and frequently become confluent, thus bringing into contact species before living in separate basins. Whereas, in the case of submergence, the freshwater species are crowded back into a constantly lessening domain and thus are affected unfavorably, in this

case the same species have a more extended range towards the sea to which the salt water is withdrawn.

As a consequence of uplift of the land and the revival of streams which have attained their baselevel of erosion, rapids and falls may be introduced in their beds. Glaciation may induce the same effect through the irregular deposition of glacial drift. Some fishes before capable of occupying the greater portion of a river basin may thus be limited in range. Essentially marine organisms, capable of enduring temporarily fresh water, may be excluded from ranging above the falls. Anadromous fishes of the families Clupeidæ and Salmonidæ, including the shad and salmon, have the habit of ascending large rivers into fresh water to breed. Shad ascend the rivers in the spring, their ascent being limited by unsurmountable falls and unfavorable temperature. It is probable that this habit of leaping falls has been acquired, and it points to a time when the practice of ascending to the headwaters of rivers did not require the exercise of this function. These fish seem then to afford us an instance in which a geographic change, common to the rivers of the northern, glaciated lands, has been met by the acquirement of a habit of leaping falls, introduced into the streams by recent uplift or glacial derangement. Without this habit, the uplift of the land, or the formation of an axis of warping across the path of a stream, or even differential wear on the bed rock so as to form a fall, might have proved destructive to a species. Instances of this kind incline us to be cautious in speculating on the extent to which geographical changes of a minor kind exercise a life and death influence on particular species of animals.

Effect of Baseleveling of a Mountainous Region.

Mr. Alfred R. Wallace has recently considered the effect of geographic vicissitudes on organisms, under the title of "Changed Conditions."* After enumerating the ordinary modifications of land and water and dependent climate in their action upon vegetation, and so on herbivorous animals, he notes that: "When such physical changes as these have taken place, it is evident that many species must either become modified or cease to exist." He further draws the con-

*Darwinism, chapter v.

clusion that "whenever the physical or organic conditions change to however small an extent some corresponding change will be produced in the flora and fauna, since, considering the severe struggle for existence and the complex relations of the various organisms, it is hardly possible that the change should not be beneficial to some species and hurtful to others."

In any land which has undergone degradation from a mountainous topography to a peneplain, we ought to find a marked change in the organisms at the close of the cycle of denudation. In the first stages of change from original constructional topography, effects will be discernable. Sculptured slopes with ravines, sharp divides and peaks, cradle species and varieties by barriers which oppose ingress and egress With the development of the umbrella-shaped topography of the island of Oahu, the land snails have varied from a common ancestral, coastal type to valley-cradled, differentiated varieties, in the upper and disjointed valleys of this dismantled, volcanic island cone.*

In the progress toward final baseleveling, the repeated diversion of streams or the reversals of drainage are a constant cause of changed conditions. The cycle begins in a mountainous tract with the least facility for migration of species, and ends in broad lowlands which favor the easy migration and wide distribution of plants and animals.

Fading away of divides.

If we follow the surface of the lands downward from an original high relief to the completed baseleveled plain, we note first that the fading away of divides will throw animals and plants before separated by barriers into one field, and that thus new adaptations between species will be enforced. Leveling off a mountain system and throwing the life of its opposite slopes into the same field would now in many parts of the world bring together species which must contest for survival.

Darwin† states that he was struck with the remarkable difference between the vegetation, the quadrupeds, and in a less degree the birds and insects, of the eastern valleys of the

*J. T. Gulick: Proc. Boston Soc. Nat. Hist., vol. xxiv, 1890, pp. 166-7.
†Journal of Researches, etc., chap. xv, Am. ed., pp. 326 and 327.

Andes and those on the Chilean side, although the climate as well as the soil was nearly the same, upon which he comments as follows:

This fact is in perfect accordance with the geological history of the Andes; for these mountains have existed as a great barrier, since the present races of animals have appeared; and, therefore, unless we suppose the same species to have been created at two different places, we ought not to expect any closer similarity between the organic beings on the opposite sides of the Andes than on the opposite sides of the ocean. In both cases we must leave out of the question those kinds which have been able to cross the barrier, whether of solid rock or salt water.

If this divergence of character has developed with the uplift of the mountain barrier, we ought, on the other hand, to expect further mutations when the barrier disappears by denudation; and the tendency of the change will be in part towards intermigration and the consequent unification of the fauna and flora. Thus on the eastern side of North America, on the two slopes of the Appalachian chain, which has been once baseleveled, the fauna and flora differ as little as possible,* yet, when this mountain system was in an Andesian youth and very high, the life of its opposite slopes must have been as strongly marked as those of the southern cordilleras at the present time.

Degradation of uplands.

Organisms suited to steep slopes and high altitudes with low temperatures† must vary, migrate up the remaining monadnocks, or keep their stations at a disadvantage as the surface sinks by denudation beneath them. The artificial transference of some species from uplands to lowlands is attended with difficulty. Thus with alpine plants transplanted in the plains, "whether from a change of atmospheric pressure or mean temperature," says Mary Somerville,‡ "all attempts to cultivate them at a lower level generally fail; it is much easier to accustom a plant of the plains to a higher situation."

*The chain still acts as a barrier to the Unionidæ, for instance. See Chas. T. Simpson, Proc. U.S. National Museum, vol. XVI, 1893, pp. 591-5; also Am. Naturalist, vol. XXVII, p. 353.

†Dr. C. Hart Merriam has shown the importance of temperature control in the geographic distribution of mammals. Smithsonian Report for 1891 (pub. 1893), p. 400.

‡Physical Geography, second Am. ed., 1850, p. 305.

Spread of lowland conditions.

Since baseleveling by meteoric agencies does not necessarily bring about the drowning out of lowland species by the encroachment of the sea, those forms which originally possessed the coastal belt will find a wider field opened to them by the degradation of the interior. If they migrate into this widening field, they may be brought into contention with those forms which have followed the surface downward. Other things being equal, the endemic lowland forms will have an advantage over those organisms which are living under the trial of altered environment with the added stress of a contest against hitherto unmet species. The new conditions comprising wider range will affect the lowland fauna and flora; it seems as if these forms should dominate over the less favored species forced down from the fading uplands.

The peneplain an open field for land life.

We have here to note perhaps the most important respect in which the new view of the origin of the ancient plains of denudation differs from the hypothesis of marine erosion. So long as it was held that plains of denudation and the great unconformities in the geological section were formed altogether or essentially by the action of the surf-mill advancing over their surface, animals and plants inhabiting the land must have undergone extermination or have sought refuge on islands, on the remaining territory, or have migrated to some land before unoccupied by them. Such even are the effects of bare submergence without actual baseleveling, stated by De La Beche* as early as 1837. By submergence, he says, "the area of dry land would be much diminished and the same amount of animals could not find room in it; there would be a considerable collision of species against species......The weaker would give way, and thus some species might be exterminated so far as the islands were concerned."

Where the process of planing off the lands was complete in the old view all land life must have been extinguished. The new view leaves the land open as a theater for land life; and the slow, gradual change in environment brought about by erosion is much more nearly in accord with the rate of alter-

*Researches in Theoretical Geology, New York, 1837, p. 217.

ation in organisms than are the rapid changes which attend submergence.

Uplift and dissection of the peneplain.

With the revival of erosion through the elevation of the land and the consequent entrenchment of the rivers in the surface of the uplifted peneplain, the subtle organic coating will feel again the changed environment. Valleys and divides, cradles, barriers, and a choice of location, will again be offered to animals and plants as a change from the monotonous conditions of the completed peneplain. Following the altered environment will come the modified organism, varied by reason of migration or isolation and the multitude of causes which geographic vicissitudes originate in the organic realm. In this change from a lowland, interrupted only by monadnocks, to a dissected upland, the lowland species will find the scales turned against them in favor of the survivors of the old highland life still clinging to the elevated monadnocks or some adjacent region of continued uplift.

PART III. THE JURA-CRETACEOUS PENEPLAIN.

From these general considerations we now turn to a period of baseleveling which is particularly well marked in North America in the existing topography and also, as I hope to show, in the organic history of the Mesozoic, the era during which the Jura-Cretaceous peneplain was elaborated. This peneplain forms the most conspicuous topographic feature in eastern North America, and traces of a plain of denudation of this date are not wanting on the Pacific coast* and over the interior of the continent. While it is yet too early to state that this peneplain was so widespread as to affect the attitude of the continent as a whole, the evidence points to this conclusion and so to the effects in the organic world which would follow from such a condition of geography in the middle Mesozoic.

The peneplain is well developed in the middle Atlantic states† and southern New England, as it is also in the south-

*Mr. J. S. Diller's generalized section across the Sierra Nevada range exhibits the outline of an uplifted, tilted and faulted peneplain. See fig. 1. Bulletin 33, U. S. Geol. Survey, p. 13.

†Prof. W. M. Davis, Rivers and Valleys of Pennsylvania. Nat. Geographic Magazine, vol. I, 1889.

ern Appalachians.* It forms the even crests and sky-lines of the mountainous ridges in Pennsylvania and New Jersey, and thence it declines beneath the sea level, forming the plane of unconformity between the upturned edges of the Jura-Trias or Newark group and the Potomac and higher beds which rest upon it. So conspicuous is this feature in the landscape of the eastern United States that it has generally attracted the attention of observant travellers. Thus, in the valley of the Ohio, we find the following description given by Bourne:†

Perhaps the best idea of the topography of this region may be obtained by comparing it to a vast elevated plain, near the center of which the streams rise and in their course wearing down a bed or valley, whose depth is in proportion to their size or the solidity of the earth over which they flow, so that our hills, with some few exceptions, are nothing more or less than cliffs or banks made by the action of the streams, and although these cliffs or banks on the rivers or large creeks approach the size of mountains, yet their tops are generally level like the remains of an ancient plain.

Non-marine beds rest on the peneplain on the Atlantic Coast.

It is a curious fact that immediately succeeding the period of erosion in which the peneplain was in great part formed, there comes, along the Atlantic coast in southern New England, New Jersey, and some of the states farther south, a series of non-marine beds, the Potomac and the lower portion of the Upper Cretaceous or Raritan group in New Jersey. These beds preclude the idea of marine erosion as the cause of the denudation which preceded them. It was at a later time in the Upper Cretaceous that the sea encroached upon the area and deposited sands and marls. The Potomac beds are referred to the border line between the Jurassic and the Cretaceous; and, if we admit their earlier age we must suppose that the Piedmont portion of the peneplain was essentially reduced to baselevel before the close of the Jurassic period.

The plant-bearing Raritan clays in New Jersey dip oceanward, according to Prof. W. B. Clark,‡ at a rate somewhat

*Hayes and Campbell. Geomorphology of the Southern Appalachians. Nat. Geog. Mag., vol. v, 1894.

†Quoted in J. H. Colton's Western Tourist or Emigrant's Guide. New York, 1846, pp. 10-11.

‡A Preliminary Report on the Cretaceous and Tertiary formations of New Jersey. Ann. Report N. J. Geol. Survey for 1892 (pub. 1893), p. 182.

steeper than that of the overlying marine Cretaceous. This fact supports the conclusion arising out of the absence of other than a few brackish water molluscan fossils in the group, that a barrier existed at this time eastward of the present shore-line, whereby the sea was partly excluded from the Piedmont area. This would make the Raritan and the older Potomac groups probably of lacustrine or estuarine origin deposited in basins formed by the warping of the baseleveled plain.

Post-Cretaceous history of the peneplain.

At the close of the Cretaceous, the peneplain and the upper Cretaceous deposits which covered its submerged seaward margin were elevated and tilted. Streams began to cut down valleys and to undergo those adjustments which had previously been outlined in the initial stages of baseleveling. Great changes in geography were made in the western or cordilleran portion of the continent. By the end of Eocene times in eastern North America, the streams had almost worked out another or Tertiary baselevel; renewed uplift caused them to sink their valleys still deeper.

The coast shelf the correlative of the peneplain.

Denudation has its counterpart in deposition. The growing coastal shelf of the Atlantic coast, including the formations newer than the Jura-Trias and older than the Tertiary, is the structural complement of the adjacent portion of the merely superficial peneplain. If the one influenced the character of the land life during its topographical development, the other had its due effect on the marine fauna. Hayes and Campbell* have recently called attention to the correlation between the sediments and cycles of baseleveling in the southern Appalachians. With the decline in the grade of the rivers debouching on the shore, the sediments became finer and finer; when baselevel was reached the stream contribution was in the form of chemical rather than mechanical waste. With the progressive shallowing of the continental submerged margin the scour of currents and efflux of tides would spread farther out from the shore-line the conditions which on deep water shores are confined to a narrow fringe below the littoral. The shoaling of

*Geomorphology of the southern Appalachians. Nat. Geog. Mag., vol. VI, 1894, pp. 123-126.

the coast through the growth of the coastal plain would tend to increase the temperature of the water on the new soundings, as W. F. Ganong* has noted as the effects of moderate uplift in recent geological times. Shoaling and straightening out of the shore-line diminish the tides, and these being less do not so much perturb through the admixture of the deeper cold water the surface waters warmed by the sun.

With the development of the coast shelf synchronously with the peneplain there was brought into existence a population of marine reptiles, the mosasaur and its allies. Just as land mammals, as we first know them, are paralleled by representative marine cetacean species, so, in the abundance of reptilian life, forms were adapted to existence in the sea and on the and

THE LIFE INHABITING THE PENEPLAIN.

Turning now to the more familiar account of the fauna and flora of the Mesozoic, we find both of these productions at the apparent opening of the era remarkably dissimilar to the Paleozoic forms. During the succeeding secondary periods equally noteworthy changes took place. Along with this rapid advance in the higher vertebrate ranks, we have the seeming fixity in some of the invertebrates after the completion of the peneplain.

The freshwater mollusca attained their present characteristics before the close of the Cretaceous.

We have to note that the freshwater mollusca of North America attained approximately their present characters during the period of evolution of the baseleveled lowlands, and that they have undergone little modification in the succeeding periods until now. "To so great a degree had this differentiation then attained," states Dr. C. A. White in his report on the Cretaceous invertebrates of the Plateau Province, "that the species of Unio, Helix, Physa, etc., seem to have been as diversified and well developed as they are at the present time. Indeed the species of these genera are so closely like some of those now living that they need only the fresh condition of recent shells to remove all suspicion of their great antiquity from the mind of the casual observer." One of these genera,

*Southern Invertebrates on the Shores of Acadia. Trans. Roy. Soc. Canada, § IV, 1890, (pp. 167-185) p. 184.

Physa, has been found in the ancient freshwater fauna of the Lower Coal Measure limestone of the Eureka district in Nevada,* a discovery which shows for how long a time the existing mollusca of the land waters have held their own on the American continent. In what has been said concerning the mutations of the drainage of the inland waters, the attempt has been made to point out the manner in which their differentiation may have been brought about. These mollusca survived the geographic changes which at the close of the Mesozoic destroyed the function of the peneplain as a lowland; in this respect the mollusca differ widely from the reptilian group, which, as we shall see, pass out as the peneplain was uplifted and dissected.

Changes of the fishes and amphibians not well understood in relation to the peneplain of this date.

While it is among the vertebrates that the most obvious alterations are found, not all of the changes are readily traced to the bearing which the lowlands of the Mesozoic might have had upon their particular groups. Among fishes the ganoids held sway as late as the culmination of the peneplain in Cretaceous times, but they gave way then to the teleosts and have now but a scanty representation in our rivers. That there was a marked change in the character of the fishes in known areas at this time is well known, but how far the differentiation of the fishes had been accomplished through these river changes is difficult to determine, particularly for the reasons that freshwater fishes are rarely found, and that these, like the mollusca, are invariably lacustrine species. We must be content with pointing out, in this place, the manner in which the river changes may have operated to modify the species.

Of amphibians, the labyrinthodonts, the first of which appeared as early as the Carboniferous, survived the Appalachian revolution, attained their grandeur in the Trias, and apparently disappeared in North America before the Upper Cretaceous. The exact cause of their decline is probably to be sought in the development of the more powerful reptilia.

*A. Hague, Geology of the Eureka District. Monog. xx. U. S. Geol. Survey, 1892, p. 87.

Reptiles and particularly the dinosaur group are correlated in development with the growth of the peneplain.

Reptiles proper are the best indices we have of the influence of the peneplain on organic life. "This class," says Le Conte,* "seems to have culminated about the end of the Jurassic or the beginning of the Cretaceous period. If their remains are more abundant in the Jurassic in Europe, they are far more abundant in the . . . . . Cretaceous in America. In fact," continues this lucid writer, "we had here in America during that time an extraordinary abundance and variety of reptilian life, including all the principal orders." With the abundance of land reptiles we find also the greatest variety of marine forms. "The reptilian type," states the venerable Dana,† "was unfolded in its complete diversity: the sea, air and earth had each its species; and there were both grazing and carnivorous kinds, of large and small dimensions." The chief of these in our interest are the Dinosaurs. "This great group of reptiles," says Marsh,‡ "were the dominant land animals of the earth during all Mesozoic time. According to present evidence, the dinosaurs were confined entirely to the Mesozoic. They were abundant in the Triassic, culminated in the Jurassic, and continued in diminishing numbers to the end of the Cretaceous period, when they became extinct."

Reptilia are characteristic lowland forms. They will endure the cold of high altitudes and latitudes only by falling into a state of torpidity. In the development of the peneplain from the high relief of the Permian, and again, at the close of the Jura-Trias, the widening out of the lowland, with plains and jungles near tide-level, followed by depression of the land, must have highly favored the water-loving reptilia. It is to these geographic circumstances, I think, that we must look for an explanation of the remarkable history of this class in Mesozoic times.

Objections arising from imperfect knowledge of the extent of the peneplain. The most serious objection which, as it appears to me, can be raised against the view that the production of broad lowlands in the middle Mesozoic favored the domi-

*Elements of Geology, third ed., 1891, p. 484.
†Manual of Geology, third ed., 1880, p. 485.
‡Am. Jour. Sci., III, vol. XXXVII, 1889, p. 331.

nance of the reptilian group, arises from the imperfection as yet of our knowledge concerning the extent and distribution of the plain of meteoric denudation of this date. It seems now clear that the baseleveling of the North American continent was so widespread as to be admitted as capable of exerting the control which is here claimed for it.* In the case of western Europe the evidence is also good, if we interpret the records in the light of our present understanding of the part played in denudation by land waters.† These two fields are so far best known for their reptilian remains. The geology of South Africa is as yet too little known to attempt a correlation in that geological province. While the present evidence would seem to correlate the distribution of the dominant dinosaur group with the lowlands of the Mesozoic about the North Atlantic, future discoveries may not only modify but controvert this opinion.

It was not until this paper was written that I became acquainted with the work of Neumayr on the geography and organic life of the European Jurassic and Neocomian periods. The fact pointed out by him that the upper Jurassic rocks extensively overlap those of the lower Jurassic, so that "the Lias was not deposited over an enormous part of the earth's surface,"‡ is paralleled by similar conditions on the North American continent in the middle Mesozoic;§ but in this western world the subsidence which followed these broad continental conditions did not come until the upper Cretaceous. It is pretty clear that the period of development of the Jura-Cretaceous peneplain was one also of broad continental conditions, a circumstance evidently favorable to baseleveling. It

*See W. M. Davis: The Osage River and the Ozark Uplift. Science, vol. XXII, 1893, pp. 276-279.

Dr. C. A. White: Correlation Papers—Cretaceous, Bulletin 82, U. S. Geol. Survey, [time-hiatus before Lower Cretaceous] p. 136: also pl. 11, ibid., "A Summary of the published Cretaceous Sections for each region" of the United States, showing time-breaks in Lower Cretaceous contrasted with deposition.

S. F. Emmons: Orographic movements in the Rocky Mountains, Bull. Geol. Soc. Am., vol. I, 1890, pp. 269-279 (Jurassic land).

†H. B. Woodward: Geology of England and Wales, first ed., 1876, pp. 399, 400.

‡Sir Arch. Geikie, Text-book of Geology, third ed., 1893, pp. 895-897.

§Dr. C. A. White, Correlation Papers, Bull. 82, U. S. Geol. Survey, p. 199.

is probable also that this broadening of the lands by elevation and coast building, by extending the field for land organisms, was favorable to the great group of reptiles. We find a parallel development of the group of mammalia when in the succeeding Tertiary periods the lands again became the present massive continents.

Objections arising from lack of knowledge of the distribution of the Mesozoic reptiles. It is not too much to say that existing reptiles are lowland forms. While a few species range to great altitudes they are so few in numbers individually and specifically as to detract nothing from the generalization. It is, however, much more difficult to substantiate this claim for the class in Mesozoic times. With the great diversity of reptilian life which then existed it is highly probable that forms were adapted to life in mountains as well as on the plains. We should expect from the affinities of the dinosaurs and what can be learned of their habits that they were water-loving forms, and hence ranged along the rivers and lake basins. Professor Marsh speaks of the Atlantosaurus as inhabiting the shores of the mountain lakes; but the bulk of this and other animals of the order makes their dwelling in a strictly mountainous region quite improbable. It seems more likely that the kangaroo-shaped dinosaurs, particularly such forms as Claosaurus, Ceratosaurus, or even Anchisaurus of the Jura-Trias, were adapted for progression over plains. But although the variety of forms was carried to such an extent, with adaptations to every habitat and station, there is little question, it seems to me, that the class was then as now mainly distributed in the lowlands.

Mammalian life unfavorably affected by the peneplain and reptilian life.

The weak marsupials or low mammals, which first appear in this country with Dromatherium in the tolerably high relief of the Trias, were apparently driven to the uplands by the more puissant and numerous reptilia of the peneplain. Their development seems also to have been retarded. This restraint of the higher class by the reptilia we may fairly attribute to the advantage which the latter derived from favorable geographic conditions. "It is a most remarkable fact," says LeConte, "that although marsupial mammals have been found

in the Jurassic and probably existed in considerable numbers then, yet not one has been found in the Cretaceous," to which he adds, "It is probable, therefore, that during the Cretaceous the marsupials which doubtless existed had been driven to some other portion of the earth, where we shall yet find their remains when our knowledge of the geology of the globe is more complete."* Professor Marsh, with the aid of Mr. J. B. Hatcher, has found, since this statement was made, the abundant mammalian remains of the Laramie beds in Dakota and Montana,† thus fulfilling a long made conjecture; but these mammals, though living at the close of the Cretaceous, are of old, lowly types, and with them were found the bones of the still dominant dinosaurs. On the east coast of North America mammalian remains are as yet unknown in the Cretaceous. If these animals existed in the region at that time their range was doubtless limited to the monadnocks. These cradles for the mammalia offered an escape from the lowland life, but presented no opportunities for preserving fossils, except where great interior lakes existed.

The close of the Mesozoic attended by the extinction of the dinosaur group and the uplift and erosion of the peneplain.

The break in organic life which occurs in the interim between the Cretaceous and the lower Tertiary is generally widespread; in a few areas such as that of the interior district of North America the passage is well recorded. There the dinosaur group passes out and gives place to new life which came in as by a bridge from some land before separated from the habitat of the reptilia. It has long been recognized that the geographic changes of this time were concerned in this organic revolution. Professor Verrill, in a lecture at Yale college, regarded lack of parental care as a probable cause of the extinction of the large and powerful reptiles of the Mesozoic age and of the large mammals of the Tertiary;‡ and Prof. Marsh has pointed out the fact, true of these reptiles as of the gigantic brutes of the American Tertiaries of which he particularly speaks, that they had brains of diminutive proportions. "The small brain, highly specialized characters and

*Elements of Geology, third ed., 1891, p. 492.

†Am. Jour. Sci., III, vol. xxxviii, 1889, pp. 81-83.

‡Quoted by E. W. Morse, Science, vol. x, 1887, p. 75.

huge bulk rendered them incapable of adapting themselves to new conditions, and a change of surroundings brought extinction."*

The late Mr. S. V. Wood attempted to adduce an explanation of the break in the character of the faunas of the Cretaceous and Tertiary periods in the European province from the geographic changes which then occurred.† He supposed that "the disappearance of the marine saurians was consequent upon that of the cestraciont fishes, the destruction of the latter having proceeded from the failure of the tetrabranchiate cephalopods which supplied their food," these in turn owing their extinction "to the entire change which took place in the position of the shores at the close of the Cretaceous period." "This change," he thought, "was so complete that such of the shore-followers as were unable to adapt themselves to it succumbed, while the others that adapted themselves to the change altered their specific characters altogether."‡ The ammonites and other chambered cephalopods of the Mesozoic, he pointed out, we have reason to believe were, like the Nautilus, bottom-feeders, and therefore shore-followers. Woodward§ supposed that the chambered cephalopods could not exist in depths exceeding 20 or 30 fathoms. The geographic change which Mr. Wood invoked was one from the littoral conditions of the Lias, Oolite and Cretaceous formations of England and northern France to the exclusion of the sea by the uplift and western extension of the European continent, so as to confine the waters of the Eocene nummulitic sea to a gulf such as that of Arabia or Persia.

In North America, the completion of the peneplain was followed first by the submergence of the later Cretaceous, then by the reversed movements of the succeeding Eocene. In the Sierra Nevadas the faulted surface of the peneplain forms the even tops of the western slopes of the range; and in eastern North America the peneplain has been differentially ele-

*Ibid.

†On the Form and Distribution of the Land-tracts during the Secondary and Tertiary periods respectively; and on the effects upon Animal Life which great changes in Geographical Configuration have probably produced. Philosophical Magazine, fourth series, vol. XXIII, 1862, pp. 160-171, 269-282, 382-393.

‡Ibid., p. 384.

§Manual of Mollusca, second ed., 1871, pp. 184, 185.

vated so as to stand at various hights, many of them mountainous. On the Pacific coast, the correlated coastal shelf was built into the Coast Range; on the east coast, the continental shelf has been slightly uplifted in the south and somewhat depressed in the north.

The Flora of the Mesozoic underwent alteration.

The change in the animal life of the Mesozoic was equalled by the alteration and advance in the character of the flora. The flattening down of the peneplain was attended by the incoming of the higher vegetable types. "Even with the Jurassic epoch, the next in succession to the Trias," says Sir J. William Dawson,* "there are clear indications of the presence of the endogens, in species allied to the screw-pines and grasses; and the palms appear a little later, while a few exogenous trees have left their remains in the Lower Cretaceous, and in the Middle and Upper Cretaceous these higher plants came in abundantly and in generic forms still extant, so that the dawn of the modern flora belongs to the Middle and Upper Cretaceous."

Mr. Alfred Russel Wallace† follows Ball's hint as to the cause of the late appearance of exogens. The suddenness of their appearance, he notes, must be only apparent, being "due to unknown conditions which have prevented their preservation (or their discovery) in earlier formations." Mr. Ball‡ has supposed that the monocotyledons and the ferns, equisetums, cycads, and conifers inhabited the lowlands, while the dicotyledons grew in the uplands, where there were less pressure, heat, moisture and CO_2 in the air; and on this Mr. Wallace remarks that, in the Rocky mountains ferns and monocotyledons are scarce in comparison with dicotyledons, dryness and rarity of the atmosphere being the cause. Elevated plateaus and mountains, he states, are more favorable to dicotyledons than to monocotyledons, and we may well suppose that the former originated within such elevated areas and were for long ages confined to them.

If we suppose that the earlier Mesozoic uplands were the

*Geological History of Plants, pp. 177, 178.

†Darwinism, Humboldt Library ed., p. 270.

‡On the Origin of the Flora of the European Alps, Proc. Roy. Geog. Soc., vol. I, 1879, pp. 564-588.

seat of the existing dicotyledons, then by the lowering of the surface by gradual consumption of the interstream areas, these forms must have been brought into conflict with the ancient flora of the lowlands and thereby forced into a contest for supremacy. The uplands which still remained in the form of monadnocks rising above the baseleveled plain served as reservoirs for replenishing any weakening in the cohorts of the endogenous species.

We should expect to find the influence of baseleveling disadvantageous to the upland flora and hence favorable to the continuation of the old Paleozoic types. The fact that the endogens prevailed in spite of this geographic change would make it seem that the upland mainly endogenous forms were hardier and accommodated themselves to the lowlands, excluding the older flora. Thus, at the base of the Upper Cretaceous on the east coast of North America, we find the dicotyledonous forms at or near sea-level in the Raritan group in the period following the baseleveling of the Piedmont plateau.

RECAPITULATION.

To sum up the faunal history of the Mesozoic alone, we have seen that *pari passu* with the creation of broad lowlands there was brought on to the stage a remarkable production of reptiles, a characteristic lowland life; and we note that the humble mammalia were excluded from the peneplain or held back in their development, so far as we know them by actual remains, during this condition of affairs until the very highest Cretaceous. At the close of the Mesozoic, the area of the peneplain was uplifted and there came into it the new life. Not only the changed geographic conditions, but the better fitted mammalia also were probably factors in exterminating the life of the peneplain. It would be more satisfactory if we could go farther in the correlation than to point out the bare correspondences in organic and geographic development which seem to be related so closely in time. In tracing these related changes attention has necessarily been called away from other perhaps equally cogent means of dispersing and modifying life. There were numerous changes of level and climate which tended to qualify and perhaps locally to nullify the effect of the peculiar geographic conditions of the Middle Mesozoic; but after admitting all these, it still seems fair to

draw the conclusion that the peneplain gave the reptilian class an advantage over the marsupials and as yet lowly organized mammalia of higher types. This may have retarded for a time the mammalia in their conquest of the lands. Without the occurrence of the conditions which produced the broad peneplain, the ongoing of the mammals might have been more quickly accomplished, but on what lines?

EXTENSION OF THE INQUIRY TO OTHER CYCLES OF DENUDATION.

If we admit the principle which I have endeavored to derive from the history of the reptilian group in Mesozoic times, we ought to be able to apply it to other fields in other times. The great unconformities which occur in the Paleozoic and in the earlier terranes of the Algonkian are, at least in part, genetically peneplains. Unfortunately our knowledge of land life prior to the Carboniferous is exceedingly meager. It is only when the processes that formed the peneplain have ceased to act upon it, through the incursion of the sea or the warping of its surface to form lakes, that the records of terrestrial life are embossed upon these monuments of erosion.

In the Carboniferous period there is reason to believe that land life was strongly influenced by geographic conditions peculiar to that remarkable epoch. There were lowlands with swamps and jungles *ad libitum*, and these were tenanted by the precursors of the reptiles of the Mesozoic, the early amphibians; but the lowlands of this period which are preserved to us were submarine platforms built up to the baselevel of meteoric erosion, rather than old lands worn down to that level.

Prior to the Carboniferous and probably also to the later Devonian epochs, a baselevel of erosion was worked out in the highlands of Scotland.* The Old Red sandstone lies almost horizontally on this ancient floor. But though we know much concerning the flora and fishes of the Devonian, and a little regarding its insects, there is not enough well known to afford a satisfactory correlation of the kind we seek to make. It is interesting to note in the Old Red sandstone another case of apparently freshwater or lake beds† resting upon what ap-

*Sir Arch. Geikie, Scenery of Scotland, second ed., London, 1887, p. 137, et seq.

†Consult Sir A. C. Ramsay, "On the Red Rocks of England of older date than the Trias," Quart. Jour. Geol. Soc., London, vol. XXVII, pp. 241-256; Sir Arch. Geikie, Text-book of Geology, second ed., 1885, p. 711; and I. C. Russell, Bulletin 52, U. S. Geol. Survey, p. 47 et seq.

pears to be an ancient peneplain, suggesting, as before noted, a confirmation of the hypothesis of meteoric denudation, followed by warping of the earth's surface.

Of the still greater unconformities in the Algonkian, the vast period anterior to the Cambrian and succeeding the now reconstructed Archean, nothing can be said.

COMPARISON OF BASELEVELING WITH GLACIATION AND SUBMERGENCE.

It remains to compare the action of the conjoined conditions which permit the formation of a peneplain with the effects produced on organic life by glacial periods on the one hand and by extensive oscillations of the land with reference to the sea, on the other.

Croll* and Darwin† have amply considered the effects of glacial periods. Ice-sheets are potent in compelling rapid migrations, the crowding of indigenous and immigrant species within narrow limits in the extraglacial territory, and in causing the annihilation of the forms which cannot escape. When the ice disappears, an unoccupied and mostly deforested field is open for all comers.

The effects of submergence and elevation of the land have been elaborated by Sir Charles Lyell in his "Principles of Geology." Submergence drowns out the land forms, or causes them to migrate; and baseleveling by marine erosion accomplishes the same result, so far as it goes.

Baseleveling by stream erosion differs from both submergence and glaciation in keeping the field open for the occupation by organisms and for those changes which are promoted by the ordinary adjustments between species. It induces change through the tendency to lower and broaden the area of lands. As this baseleveling advances in a region, the likelihood of submergence increases, since, the coast being lower, a less depression will cause the sea to flow far inland; it decreases the chance of glaciation, for, the land being lower, the surface is farther removed from the snow line.

Periods of baseleveling are characterized by relative stabil-

*On Geological Time, Part III. Inquiry into the effects of Icebergs, Interglacial Periods, etc. Philosophical Magazine, Nov., 1868.

†Origin of Species, ch. XII.

ity, periods of glaciation, by relative instability, of the land with reference to the sea.

Baseleveling of itself is not destructive to land life; both glaciation and marine invasion are sterilizing in their effects.

The theory of the subaërial origin of plains of denudation helps our conception of the conditions which have favored the continuity of land life on the earth; the theory of marine denudation compels us to adopt for the same time and place the conclusion that land life was driven out. The former, newer view is in accord with the fact that the fauna and flora of a country is more closely related to antecedent fossil forms than to exotic life; it is also consistent with the theory that the existing continents have long stood as dry lands, though temporarily invaded by the sea.

TERTIARY AND EARLY QUATERNARY BASELEVELING IN MINNESOTA, MANITOBA, AND NORTHWESTWARD.*

By Warren Upham, Somerville, Mass.

CONTENTS. PAGE.

Baseleveling of the Cretaceous northwestern plains during the Tertiary era.

From the valleys of the Mississippi and Minnesota rivers, the Red river of the North, and lake Winnipeg, a broad area of plains ascends gradually westward to the foot of the front ranges of the Rocky mountains. The first ascent from the Minnesota and Red river valleys and from the flat country enclosing lakes Winnipeg, Manitoba and Winnipegosis is mainly by an abrupt escarpment, eroded in the Cretaceous strata

*Read before the Geological Society of America at the Brooklyn meeting, Aug. 15, 1894.

forming the eastern border of the plains. The altitude of these valleys and of the Manitoba lake region ranges from 1,000 to 750 feet above the sea; and the escarpment, which, as viewed from the lowlands on the east, is named in its successive portions from south to north the Coteau des Prairies, the Pembina, Riding, and Duck mountains, and the Porcupine and Pasquia hills or mountains, rises from 200 or 300 feet to 1,000 feet within a few miles, its crest being mostly 1,500 to 2,000 feet above the sea level. Thence westward the expanse of the plains, broken here and there by eroded valleys and tracts of sometimes very irregular denudation, has nevertheless for the greater part a very uniform nearly flat or moderately rolling surface, which rises on the average four or five feet per mile, to a hight somewhat exceeding 4,000 feet above the sea at the foot of the Rocky mountains in Montana and Alberta on the opposite sides of the United States and Canadian international boundary.

The geologic strata of this northern portion of the great plains are the Dakota, Colorado, Montana and Laramie formations of late Cretaceous age, whose deposition took place during the closing part of the Secondary or Mesozoic era. Southward, in the United States, the plains comprise extensive deposits of Tertiary lacustrine beds, representing the continuation of the brackish water and finally lacustrine conditions which prevailed over large areas of the plains during the Laramie period; but in the northern region considered by this paper no Tertiary beds are found. Since the beginning of the Tertiary era this region has been a land surface undergoing denudation. When its marine and lacustrine deposits were first raised to be dry land they had a monotonously flat surface. A very long cycle of baseleveling ensued, beginning as soon as this northern part of the plains was uplifted at the end of Cretaceous time and continuing nearly or quite to the end of the Tertiary era. During this time the surface was gradually lowered by the action of rains, rills, rivulets, creeks and rivers, until it was mostly reduced to a baselevel of subaërial erosion.

Areal and Vertical Extent of this Baseleveling.

Across an area 700 or 800 miles wide from east to west on the international boundary, and of much greater extent from

south to north, the processes of baseleveling were at work through the vast duration of Tertiary time, cutting down the plains far below their original surface. But here and there isolated areas of hills and even mountains remain, consisting of remnants of the horizontal Cretaceous strata which elsewhere have suffered erosion.

The most noteworthy eastern highland area of this kind is the Turtle mountain, lying in the north edge of North Dakota and the south edge of Manitoba, its extent on the international boundary being about 40 miles, with two-thirds as great width. This high tract, diversified by many subordinate hills and short ridges, 50 to 300 feet above adjoining depressions, rises with a massive general form suggesting, as seen from some distant points of view, the rounded back of a turtle; but as seen from the south or north, its many hills and buttes present a serrated outline. Its altitude above the surrounding country is 300 to 800 feet, the summits of its highest hills being about 2,500 feet above the sea. Beneath a veneering of glacial drift, which is in large part morainic and generally strown with many boulders, averaging perhaps 50 to 75 feet in thickness, Turtle mountain consists of nearly horizontally bedded Laramie strata, chiefly shales, with very thin seams of lignite. At or below the base of this highland, the freshwater Laramie formation rests on the marine series, which comprises the Fox Hills sandstone and Fort Pierre shales, the two great shale formations being separated by a sandstone stratum which outcrops in North Dakota on Ox creek and Willow river and on the Souris river between Minot and its most southern bend. A thickness of not less than 500 to 1,000 feet of the Laramie and Montana (Fox Hills and Fort Pierre) strata has been carried away from the surrounding eastern part of the plains.

Westward the depth of the Tertiary baseleveling was greater. Around the Highwood and Crazy mountains, in central Montana, according to Prof. W. M. Davis* and Dr. J. E. Wolff,† the erosion of the plains has a vertical extent of 3,000 to 5,000 feet. Perhaps the most striking evidence of

*Mining Industries of the United States, Tenth Census, vol. xv, pp 710, 737, 745.

†Bulletin, Geol. Society of America, vol. III, 1892, pp. 445-452.

this great erosion is afforded by the range of the Crazy mountains, which lies immediately north of the Yellowstone river, near Livingston, and is conspicuously seen from the Northern Pacific railroad. These mountains trend slightly west of north, and extend about 40 miles with a width of 15 miles, attaining an elevation of 11,178 feet above the sea, and 5,000 to 6,000 feet above the prairies at their base. Their structure has been thoroughly studied by Wolff, who finds that they consist of late Cretaceous strata, soft sandstones, nearly horizontal in stratification, intersected by a network of eruptive dikes. The more enduring igneous rocks have preserved this range, while an average denudation of not less than one mile in vertical amount reduced all the adjoining region to a baselevel of erosion. The Highwood mountains, about 25 miles east of Great Falls, having a hight of 7,600 feet above the sea or about 3,500 feet above their base, are described by Davis as displaying the same structure and therefore similarly testifying of great denudation.

The uplift at the beginning of the Tertiary era appears to have raised this portion of the plains to a hight above the sea as great as the vertical extent of their Tertiary erosion, that is, to a hight of at least 1,000 to 5,000 feet, increasing from east to west. Toward the end of this era the baseleveling had reduced the country mostly to a plain which was probably only a few hundred feet above the sea, lying much below its present altitude.

Renewed Elevation and partial Baseleveling at the close of the Tertiary and during the early part of the Quaternary era.

Between the general Tertiary cycle of baseleveling and the Glacial period, there intervened a second great epeirogenic uplift, as shown by a return of the conditions of vigorous stream erosion and a new cycle of partial baseleveling, by which wide flat valleys were cut in the eastern part of these Cretaceous plains. In Manitoba the northeastern border of the formerly baseleveled expanse was removed, the Cretaceous beds being eroded to the underlying Archean and Paleozoic rocks upon a large area bounded on the west by the escarpment before mentioned as now forming the eastern limit of the plains.

The duration of the earlier baseleveling apparently coincided, as to both beginning and end, with the Tertiary or Somerville cycle of partial baseleveling which Davis and Wood have studied in Pennsylvania and northern New Jersey and believe to have affected a large area of the other eastern states.* The termination of the denudation forming the western plains, and their uplift to undergo the erosion of the Red river valley and of the present Assiniboine and Saskatchewan valleys, were probably also contemporaneous with the great epeirogenic movement which in California, according to Mr. J. S. Diller, ended a long cycle of baseleveling that had extended through the whole of Cretaceous and Tertiary time, and raised a part of that baseleveled district at the beginning of the Quaternary era to form the lofty Sierra Nevada.† Again, the same record of long continued baseleveling, followed by uplift and a new cycle of rapid valley-erosion, is found by Powell‡ and Dutton§ in the plateaus and Grand canyon of the Colorado. The broad denudation above these plateaus, when compared with the studies thus noted in other regions, and with the total erosion of the canyon seems to have required not only the Eocene and Miocene periods, but also most of the Pliocene; for the ratio of the denudation to the canyon-cutting must be nearly or quite as great as that between the duration of the entire Tertiary era and the comparatively short time since its close. Instead of referring the division of these parts of the history of the Grand Canyon district to the beginning of the Pliocene, as was done provisionally by Dutton, it may therefore mark the final stage of the Pliocene period and the inauguration of the Quaternary era. In the southern and eastern United States, according to McGee, a similar great uplift of the land, with very extensive erosion,

---

*Proceedings, Boston Society of Natural History, vol. XXIV, 1889, pp. 365-423. National Geographic Magazine, vol. I, 1889, pp. 183-253; vol. II, 1890, pp. 81-110.

†U. S. Geol. Survey, Eighth Annual Report, for 1886-'87, pp. 428-432. Journal of Geology, vol. II, pp. 32-54, Jan.-Feb., 1894. Compare also articles by Prof. Joseph Le Conte, Am. Jour. Sci., III, vol. XIX, pp. 176-190, March, 1880; vol. XXXII, pp. 167-181, Sept., 1886; vol. XXXVIII, pp. 257-263, Oct., 1889.

‡Exploration of the Colorado River of the West, 1875. Geology of the eastern portion of the Uinta Mountains, 1876.

§U. S. Geol. Survey, Monograph II, "Tertiary History of the Grand Cañon District," 1882.

intervened between the deposition of the Lafayette formation and the Ice age; and, in a recent paper before this Society, I have shown that the successive Lafayette epochs of deposition and erosion are also recognizable in this more northern area drained principally by the Nelson river.*

ORIGIN OF THE RED RIVER VALLEY AND THE MANITOBA ESCARPMENT BY THIS LATER EROSION.

East from the foot of the Pembina, Riding, and Duck mountains and the hills farther north, together called the Manitoba escarpment by Mr. J. B. Tyrrell, of the Canadian Geological Survey, Cretaceous strata have not been found, so far as I have learned, in Manitoba, nor in the region north and northeast from lake Winnipeg to Hudson bay. It seems quite certain, however, that Cretaceous beds continuous from this escarpment extended eastward at the end of the Tertiary baseleveling so far as to cover the area of lake Winnipeg. As Hind and Dawson have well pointed out, it was by the erosion of the eastern portion of these beds, after the great western expanse of the plains had received nearly its present form, that this steep escarpment was produced.† At the time of uplifting of the plains near the beginning of the Quaternary era, this great baseleveled region appears to have stretched from the Rocky mountains to the Archean hills on the eastern border of the area of the later glacial lake Agassiz. The east margin of the soft Cretaceous strata was then anew subjected to rapid erosion, with the result that it was almost wholly worn away to the floor of the Archean gneiss and granite and Paleozoic limestones upon a width of 100 miles or more and to a depth westward of 300 to 1,000 feet as shown by the hight of the Pembina mountain and Manitoba escarpment.

In Minnesota and North Dakota the flat Red river valley plain, averaging 50 miles wide, with a depth of 200 to 500 feet below the country on each side, and extending more than 200 miles from south to north, opening into the Manitoba lake area, appears also to have been eroded at the same time. The

*Bulletin, Geol. Society of America, vol. v, 1894, pp. 87-100.

†H. Y. Hind, Report of the Assiniboine and Saskatchewan Exploring Expedition, Toronto, 1859, pp. 168, 169; Narrative of the Canadian Exploring Expeditions, London, 1860, vol. II, pp. 48, 55, and 265. G. M. Dawson, Geology and Resources of the Forty-ninth Parallel, 1875, pp. 253, 254.

conspicuous Pembina mountain escarpment of Cretaceous shales, overspread by drift, on the west side of this valley, deep wells penetrating through the drift to Cretaceous beds and older strata along the low valley plain, and the topographic features of the land rising eastward from it with nearly the same rate of ascent as on the west, lead to the belief that the eastern like the western border of this wide valley is formed by an escarpment of Cretaceous shales beneath the drift. The baseleveled plain of the Tertiary era has been broadly and deeply channeled during a later time of high continental uplift, contemporaneously with the erosion of canyons in the western and southwestern United States, and with the excavation of the lower Mississippi valley, of the Delaware and Chesapeake bays, and of other estuaries on our southern Atlantic coast.

OUTLYING REMNANTS OF CRETACEOUS FORMATIONS EAST OF THE MANITOBA AND PEMBINA ESCARPMENT.

Although no Cretaceous beds have been reported on the north side of the international boundary east of the Manitoba escarpment, it may be expected that their remnants will yet be found in central and eastern Manitoba. Southward in central and southern Minnesota, frequent Cretaceous outcrops are known, and in numerous places deep wells, after passing through the thick covering of glacial drift, encounter Cretaceous shales and sandstone, which in some instances are found to reach to a thickness of several hundred feet. Further evidence of the eastward extent of Cretaceous formations in this state is afforded in its northern part by Mr. H. V. Winchell's discovery of Cretaceous shales in place on the Little fork of the Rainy river* and on the high Mesabi iron range.† Lignite fragments, probably derived from the erosion of Cretaceous strata, are also occasionally found in the glacial drift upon the country south of the Lake of the Woods and between Rainy lake and Vermilion lake. Next beneath the drift, a considerable depth of Cretaceous beds probably still exists upon the greater part of the western two-thirds of Minnesota.

*Geol. and Nat. Hist. Survey of Minnesota, Sixteenth Annual Report, for 1887, pp. 403-9, 431, 434.

†AM. GEOLOGIST, vol. XII, pp. 220-223, Oct., 1893.

Concerning their eastern limits, Prof. N. H. Winchell, the state geologist, writes:

A line drawn from the west end of Hunters' island, on the Canadian boundary line, southward to Minneapolis, and thence southeastwardly through Rochester to the Iowa state line, would, in general, separate that part of the state in which the Cretaceous is not known to exist from that in which it does. It is not here intended to convey the idea that the whole state west of this line is spread over with the Cretaceous, because there are many places where the drift lies directly on the Silurian or earlier rocks; but throughout this part of the state the Cretaceous exists at least in patches, and perhaps once extended continuously.*

TOPOGRAPHIC FEATURES OF MINNESOTA AND MANITOBA DUE TO THESE CYCLES OF BASELEVELING.

Cretaceous deposits originally overspread all of Minnesota and Manitoba, excepting possibly portions of their eastern borders. The long Tertiary cycle of baseleveling greatly reduced the thickness of these beds, but their part remaining at the end of the Tertiary era appears to have still formed a general envelope, with mostly a nearly level surface, above the older rocks for a distance of 100 to 200 miles eastward from the Manitoba escarpment, the Pembina mountain and the Coteau des Prairies. Occasional tracts of hills, as the Turtle mountain, or a great highland ridge, as the Coteau des Prairies,† rose 500 feet or more above the general level.

With the ensuing epeirogenic uplift which marked the transition from the Tertiary to the Quaternary era, the streams again began a vigorous work of erosion. The broad Red river valley, with its enclosing escarpments, and the low lake district of Manitoba, with the great escarpment on the west, then were sculptured to nearly their present forms.

In various parts of Minnesota, as Langhei and the vicinity of Glenwood in Pope county,‡ conspicuous highland tracts and the depressions occupied by lakes seem attributable to the contour of the Cretaceous beds beneath a somewhat uniform mantle of the glacial drift. Another district of similar features is the neighborhood of Pokegama lake on the upper Mississippi and all the country thence westward to lake Itasca. The Pokegama lake, with its irregular arms, proba-

*Bulletins of the Minnesota Academy of Natural Sciences, vol. I, p. 348. Compare also Geology of Minnesota, Final Report, vols. I and II.

†Geology of Minnesota, vol. i, 1884, pp. 593, 601, etc.

‡Ibid., vol. ii, 1888, p. 492.

bly fills the hollows due to the valleys of a preglacial river and its tributaries, not wholly concealed by the overlying drift. Within a few miles southwestward, a ridge several miles long and about 300 feet above the lake, singularly prominent in contrast with the surrounding moderately undulating or somewhat hilly surface, is reported by Prof. G. E. Culver, in his exploration of that district for the Minnesota Geological Survey, to consist probably of Cretaceous shales beneath a deposit of till which has partly a smooth surface but on the northern slope presents a profusion of morainic knolls and hillocks. In a third and larger area, north and northwest of Red lake, where an extensive island arose above the highest stage of lake Agassiz, the grand topographic features seem likewise due to the prominence of the Cretaceous beds, there deeply drift-covered.*

In North Dakota and Manitoba, west of the Cretaceous escarpment, hills and buttes of the Cretaceous shales, thinly covered by drift, occur rarely along the Sheyenne river; in the vicinity of Devil's lake, one of especial prominence being the Big butte, about ten miles west-northwest of this lake; and near the Pembina river, where Star mound and Pilot mound in Manitoba are examples. Proceeding farther westward, and especially northwestward in Assiniboia, such comparatively small hills, besides also large hilly tracts similar to the Turtle mountain, are found more frequent.

DIRECTION OF THE TERTIARY AND EARLY QUATERNARY DRAINAGE.

The early Quaternary epeirogenic uplift causing the erosion and baseleveling of the Red river valley and Manitoba lake district must evidently have occupied a long period as measured by thousands of years. Its duration may well have been coextensive with the Lafayette period, embracing the deposition and erosion of the Lafayette formation, which in my previous paper already cited I estimate to have comprised together some 60,000 to 120,000 years.† During this period the drainage from the entire area of the present Nelson river basin probably passed, nearly as now, toward the north and northeast. With the greater continental altitude of that time a river system much longer than that of the Nelson and its feed-

*AM. GEOLOGIST, vol. xi, pp. 423-425, June, 1893.

†Bulletin, Geol. Society of America, vol. v, pp. 97, 99.

ing streams, the Rainy and Winnipeg, Red and Saskatchewan rivers, flowed northeasterly through a vast nearly flat plain and thence eastward along a great valley bounded by highlands, where now we have the Hudson bay and strait.

The drift-covered Cretaceous highland tract called the Coteau des Prairies, terminating at the north, about twenty-five miles west of lake Traverse, in a bold headland, surrounded on all sides excepting the south by a nearly level expanse 800 feet lower and about 1,200 feet above the sea, appears to have stood, during both the Tertiary and Quaternary cycles of baseleveling, in the angles between confluent streams which flowed to the north. Both the Tertiary and early Quaternary rivers from this part of the continent probably had their mouths on or south of the area of Davis strait; for the absence of marine Tertiary formations from the coasts of the northern half of North America testifies to their having held a greater altitude throughout that era than now.

RELATIONSHIP OF THE LATER BASELEVELING TO THE ICE AGE.

Flowing so great distances before reaching the sea, the rivers of both these cycles of baseleveling may have denuded their areas of drainage, during the first cycle very completely and during the second partially, to broad plains, while yet the altitude of the Manitoba lake region equalled or exceeded that of the present time. Lake Winnipeg is 710 feet and lake Manitoba 809 feet above the sea. Newly uplifted as a high plateau during the early portion of the Quaternary era, this north part of the continent, rising probably somewhat faster in the Arctic region than farther south, may have continued to present favorable conditions for the baseleveling of the Red river valley and the district of the great Manitoba lakes until the mean altitude of the area which became covered by the North American ice-sheet and its drift was 3,000 to 5,000 feet higher than now, as indicated by the fjords and submarine valleys of our northern Atlantic, Arctic, and northern Pacific coasts. The culmination of this uplift appears to have brought so cold and snowy climate that a vast sheet of snow and ice was gradually accumulated, under whose weight the land finally sank mostly somewhat below its present hight, causing the ice-sheet to be melted away, with deposition of its glacial and modified drift.

COMPARATIVE ESTIMATES OF THE AMOUNT OF EROSION IN THIS REGION DURING TERTIARY TIME, AND DURING THE LAFAYETTE, GLACIAL, AND RECENT PERIODS OF QUATERNARY TIME.

Along the distance of about 800 miles from the Lake of the Woods west upon the international boundary to the Rocky mountains, the depth of the Tertiary denudation ranged from 500 feet to 3,000 feet or more. Its average amount may therefore be estimated as 1,500 to 2,000 feet, or about a third of a mile, so that the cross-section of the strata removed along this line would be represented approximately by 267 square miles.

During the early Quaternary or Lafayette period of renewed epeirogenic elevation, the denudation on a width of about 100 miles, extending across the Red river valley to the Pembina mountain, ranged probably from 100 feet or less to 400 or 500 feet, with increase from east to west, and its average was apparently as much as 250 feet, giving a cross-section approximately equivalent to five square miles. On the area of the plains, for the 700 miles from the Pembina escarpment to the mountains, the contemporaneous erosion may be estimated to average 25 feet in depth, giving about two and a half square miles as the measure of its vertical section.

The material eroded during these baseleveling cycles was borne far away into the North Atlantic ocean; but the erosion effected by the ice-sheet in the Glacial period subtracted nothing from the land surface as a whole. The ice-sheet simply wore off the superficial beds of preglacial alluvium and residuary clay and portions of the bed-rocks over which it was amassed, bore these commingled materials onward with its motion, and deposited them at various distances southward from their preglacial sources. In this process many small hillocks and tower-like masses of the Cretaceous and older strata, similar to the fantastically eroded hills, plateaus, and pinnacles of the driftless area in Wisconsin, were worn down and leveled by the overriding ice, and the deep valleys of preglacial erosion were partially or wholly filled with the glacial drift. The mean thickness of the drift along these 800 miles of the international boundary may probably be about 50 feet, its maximum thickness, which is deposited in the Red river valley, being 150 to 300 feet. Taking its average as 50 feet on an extent of 800 miles, the vertical section of the gla-

cial erosion and deposition will be represented by about eight square miles.

During the geologically short Postglacial or Recent period, which has been shown by the independent but well agreeing observations and measurements of N. H. Winchell, Gilbert, Andrews, Wright, and many others, to have comprised only some 6,000 to 10,000 years, the material eroded here has been again undergoing transportation to the sea or to the Manitoba lakes or lower portions of the great avenues of drainage. In this period the amount eroded from the surface along these 800 miles probably has not averaged more than two or three feet, its total section therefore being represented by about two-fifths of a square mile.

These approximate measures of the denudation along the international boundary during the successive divisions of time since the Cretaceous period seem consistent with the estimates presented in my former paper, that the duration of the Tertiary era was probably between two and four million years; of the Lafayette period, between 60,000 and 120,000 years; of the Glacial period, perhaps 20,000 to 30,000 years; and of the Recent period, between 6,000 and 10,000 years.

INTERRUPTION DURING THE DEPOSITION OF THE BURLINGTON LIMESTONES.

By Francis M. Fultz, Burlington, Iowa.

The lithological characters of the different strata of the Burlington limestones are quite generally the same. Even the upper division does not differ materially from the lower. Of course some of the layers are more compact than others, a few even being massive and crystalline enough to resemble marble. Yet whether massive or not they have a common origin. They are all crinoidal. With the exception of a very few layers you could scarcely find a cubic inch of rock that does not plainly show its crinoidal origin. Between the beds of limestone are found a few layers of shales, clays, etc., but they form but a comparatively small part of the whole.

It has generally been conceded that the deposition of the whole Lower Carboniferous group in southeastern Iowa was

uninterrupted. I quote from White, Geology of Iowa, 1870, Vol. I, page 202: "The accumulation of the strata of the sub-Carboniferous group in southeastern Iowa, from the Lower Burlington limestone to the St. Louis limestone inclusive, was evidently uninterrupted." And this seems to have been the generally accepted belief. I question the truth of the statement and think evidence can be furnished to show that there were disturbances and cessations of deposit within the period indicated. It is quite probable that there was some disturbance at the close of each of the subdivisions; but the instance I shall bring forward occurs well within the limits of one of them.

Evidence of disturbance and cessation of deposit is threefold, viz.: more or less abrupt changes in fossil forms, change in lithological characters, and erosion with consequent unconformity. At present I shall confine myself exclusively to the last mentioned evidence, although elsewhere* I have given my views on each of the three and discussed their bearing on each other.

Almost everywhere in the vicinity of Burlington, where the upper division of the Burlington limestone is exposed, there occurs, somewhat below the middle, a stratum of heavy bedded white limestone about 6 ft. in thickness. Generally underlying this there is either a thin stratum of blue clay or a yellow sandy limerock. Immediately overlying there is uniformly found a bed of tough blue shale. The abrupt change in the lithological character of the deposit, coupled with a somewhat marked change in fossil forms, led me to believe that there must have been some disturbance and possibly a cessation of deposit. This belief was strengthened by the fact that the surface of the limestone at various places exhibited a somewhat water-worn appearance.

In the southern part of the city limits of Burlington, at a locality known as "The Cascade," there are several quarries in which nearly the whole depth of the Upper Burlington limestone is worked. The massive white layer spoken of furnishes a goodly part of the rock taken out. It was in one of

*Paper read at the meeting of the Iowa Academy of Science, December 26 and 27, 1893.

these quarries that I came across the most conclusive evidence of erosion.

The Cascade ravine is about half a mile in length and enters the Mississippi river at right angles. About one-fourth of a mile back from the mouth of the ravine these quarries occur. One of them is on the south bank and is situated on both sides of a short, but deep lateral ravine, the bottom of which is several feet lower than the stratum of white limestone. In working off the corner between the main and lateral ravines the white limestone layer was found to be much eroded and the blue shale was uniformly deposited directly

FIG. 1. UNCONFORMITY OF UPPER BURLINGTON STRATA.
[The white patches in the shale are marks made by the quarryman's pick.]

upon the water-worn surface, and conforming to all of its irregularities and inequalities. The erosion is lateral more than vertical and the inequalities are quite abrupt, one bench amounting to fully two feet: and yet the blue shale covers this without a break. The shale is itself capped with fairly well-bedded limestone. The contact of the shale with the limestone is well shown in the accompanying figure.

This is direct evidence of erosion in the first half of the Upper Burlington epoch. An interesting fact which necessarily follows is that the present system of drainage must have

had its origin at that time. The position of the eroded surface of the limestone and the inclination of the directly superimposed strata both seem to indicate that the lateral ravine had its beginning at that early date. Of course the principal ravine must have existed to furnish an outlet. Along its banks the white limestone layer is not exposed, being covered with a heavy mantle of drift. In all the quarries worked at this point the upper strata show a decided dip towards the main ravine, which goes to confirm the theory as to the early origin of the drainage system.

At other localities in this county I have noticed evidence of erosion, but in no case was it so pronounced as in the instance just given. I expect to find further evidence of disturbance in the line of unconformity.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Lower Silurian Lamellibranchiata of Minnesota. By E. O. ULRICH. (Chapter VI of volume III of the Final Rept., Geol. and Nat. Hist. Survey of Minn., pp. 475-628, plates 35-42; June 16, 1894.) The structure and affinities of the early Palæozoic lamellibranchs have been but meagerly exploited. The stupendous work of Barrande upon these and later forms of the Bohemian Palæozoic has perhaps overwhelmed as much as aided students of other Silurian faunas, and as far as pertains to the American species Mr. Ulrich has had a fair field, a magnificent opportunity, and has acquitted himself admirably and with signal credit to the Geological Survey of Minnesota.

After a few instructive introductory pages on the general relations, nomenclature and preservation of these fossils, the author gives a scheme of classification for all Palæozoic genera (in which, however, we observe none of those introduced by Frech and Whidborne). Then follows the systematic part of the work, the principal innovations of which we briefly notice.

The familiar genus *Ambonychia*, Hall, usually construed from the well known form *A. radiata* Hall, is here strictly limited to shells having the structure of the type, *A. bellistriata*, that is, without lateral teeth or byssal opening and with an internal anterior lobe set off by a thin vertical internal plate.

Clionychia, Ulrich (type, *Ambonychia lamellosa* Hall), is an elementary form without cardinal or lateral teeth or the vertical plate of *Ambonychia*.

Byssonychia, nov. (type, *Ambonychia radiata* Hall), possesses a byssal opening and both cardinal and lateral teeth.

The genus *Modiolopsis*, Hall, is carefully restricted and its close generic relation to the Devonian *Modiomorpha* pointed out.

Eurymya, nov., is founded upon Hall's species *Modiolopsis plana*, and is distinguished by its posterior ala and striated ligamental area.

Actinomya, changed in the errata to *Whitearesia*, nov. (type, *Modiolopsis cincinnatiensis* Hall and Whitfield), bears surface radii, is without cardinal teeth, and has a short ligamental groove on each side of the beak.

Modiolodon, nov. (type, *Modiolopsis oviformis* Ulrich), is similar to *Modiolopsis*, but has cardinal teeth on each valve.

Colpomya, nov. (type, *C. constricta* nov.), has the external form of *Modiolopsis*, but possesses a strong rostral tooth-like process in each valve.

Aristerella, nov. (type, *A. nitidula*, nov.). Similar to *Actinomya*, except in its inequal valves.

Endodesma, nov. (type, *E. cuneatum*, nov.). These are ventricose but edentulous shells with well defined lunule and extremely faint muscular scars.

Psiloconcha, nov. (type, *P. grandis* Ulrich), embraces elongate, compressed shells with edentulous hinge and linear ligamental groove.

Prolobella, nov. (type *P. striatula*, nov.). The author considers Conrad's *Avicula trentonensis* a member of this new genus, but this is a species which Jackson has placed among the probable members of his genus *Rhombopteria*, the generic radicle of the aviculoids.

Whitella, Ulrich (type *W. obliquata* Ulrich): short, ventricose shells with prominent umbones, sharply defined escutcheon, and two to five oblique teeth in front of the beaks.

Plethocardia, Ulrich (type, *P. umbonata* Ulrich): tumid shells with enrolled beaks. "A strong and large process projects forward and downward from the under side of the hinge beneath the beak of each valve," and the shell bears a strong linear lateral tooth.

Ctenodonta, Salter (a name which the author adopts in preference to Hall's earlier term *Tellinomya*), is divided into six groups, designated not by subgeneric terms, but by the names of characteristic species.

Allodesma, Ulrich (type, *Modiolopsis subelliptica* Ulrich), is applied to small shells with anterior beaks, strong anterior adductor scars margined within by an elevated ridge, hinge with cardinal, posterior lateral, but no anterior lateral teeth.

Rhytimya, nov. (type, *R. producta*, nov.), is regarded as a pholad and allied to *Pholadella*, *Cimitaria* and *Allorisma*.

Saffordia, nov. (type, *S. ventralis*, nov.). Small shells similar to *Grammysia*, with sharply defined lunule and very large external ligament groove.

The total number of species described is 130, divided as follows: *Ambonychia* 4, *Clionychia* 5, *Byssonychia* 2, *Modiolopsis* 11, *Eurymya* 1, *Actinomya* (*Whitearesia*) 2, *Orthodesma* 4, *Modiolodon* 2, *Colpomya* 1, *Aristerella* 1, *Endodesma* 5, *Psiloconcha* 1, *Prolobella* 1, *Cyrtodonta* 16, *Vanuxemia* 15, *Matheria* 1, *Whitella* 12, *Plethocardia* 2, *Ctenodonta* 26, *Cleidophorus* 2,

Lyrodesma 3, *Technophorus* 4, *Allodesma* 1, *Rhytimya* 1, *Cuneamya* 2, *Sphenolium* 2, *Saffordia* 3.

One cannot but admire the astuteness of observation manifested throughout in the treatment of the subject-matter, and appreciate the service rendered by the author toward a better comprehension of these fossils. The illustrations are in photo-engraving, but are eminently satisfactory. J. M. C.

The Iron-bearing rocks of the Mesabi Range in Minnesota. By J. EDWARD SPURR. pp. VIII, 268, with 12 plates and 22 figures in the text. (Bulletin No. 10, Geol. and Nat. Hist. Survey of Minnesota, Minneapolis, 1894.) This monograph is by far the most important contribution so far made to the geology of this recently discovered lake Superior iron ore district. The result of only one year's work in the field and laboratory, it contains some new facts bearing on the genesis of these iron ore deposits and many suggestive ideas applicable to iron ores in general.

To the student of the geology of lake Superior iron ranges the most interesting portion of the bulletin is that which goes to prove that the original form of the iron ore was not a carbonate of lime and iron mingled with more or less silica—the cherty carbonate of Irving and Van Hise—but that it was a ferrous silicate and that the cherty carbonate is in all instances an alteration product from this silicate and only one stage in its change to the final form of oxide of iron. Still more interesting is the suggestion that this ferrous silicate was in all probability the product of Foraminifera and existed as the mineral glauconite. The chemical analysis and petrographical study of the iron-bearing rocks seem to harmonize in support of this view, which, although not entirely original as an explanation for possible iron ore deposits, is yet new in its application to any particular deposits of great extent and especially in rocks of such great geologic antiquity as those of the Mesabi. It must be admitted that the demonstration will not be complete until the actual discovery of organic remains. But the author is perhaps deserving of so much the more credit for working out so strong a case before the discovery has been made.

The stratigraphy of the Mesabi is found to be substantially as given in the Twentieth annual report of the Minnesota Survey. Certain faults are described in the central portion of the range which had not been previously noticed and for the existence of which the evidence given does not yet appear to be conclusive. The author argues that the ore deposits have been produced along lines of fracture and weakness, and because he finds ore deposits in a certain locality he straightway assumes the presence of a fault plane there, and explains the accompanying phenomena accordingly.

The different phases of the iron-bearing rock and their transition from one to another are described with such elaborate fullness as to be rather confusing to any but a careful reader and student of the text; but it is in such full statements of the evidence that we find the basis for the conclusions drawn as to the original nature of the rocks.

Undue stress seems to be laid upon the idea that none of the banding of the taconyte is due to sedimentation. It is admitted by the author that the rocks were water-deposited—chemical and mechanical—and it would be extremely surprising if all the banding now so beautifully displayed in the ore and rock alike were due to secondary segregation and none of it to the original separation by specific gravity or the contingencies of sedimentation.

The specimens examined by the author exhibited a smaller percentage of fragmental material than would be expected from a macroscopic examination. Indeed, it is difficult to conceive that the taconyte with a thickness of 800 feet can be so completely due to chemical deposition as our author would have us believe.

The ore deposits are believed to owe their existence to chemical solutions which percolated from the surface downward. The rules deduced are that in regions of comparatively free oxidation chalybeate waters deposit iron and remove silica; while in regions of scant oxidation silica is deposited and iron is carried away in solution. The principal solvents are believed to have been oxygen and carbonic acid, with sulphuric acid and alkalies as secondary reagents.

Plates X, XI and XII are double-page maps, showing the geology and topography of the central portion of the Mesabi. The area occupied by the various rock formations and the location of the ore bodies already found are shown quite accurately. These maps furnish the best guides for future explorations that can be found, but the report itself is too technical to be of use to the ordinary prospector.

As a geological study of the range, this report is of the highest value and reflects great credit upon its author. H. V. W.

The nickel ores of Sudbury, Canada. By JOHN D. FROSSARD. pp. 61, Geo. Philip and Son, London, 1893. Chiefly a compilation from various articles on the subject without discrimination as to their value and accuracy, this little book presents little new information. Its chief merit lies first in its practical data referring to the average cost of production and quality of the ore at Sudbury, and second, in the fact that it is a sort of a little monograph on nickel ores in general. It is also useful in giving references to the literature from which more detailed and exact information may be gained. H. V. W.

Mining Royalties, their practical operation and effect. By CHAS. A. JAMES. pp. 277, Longmans, Green & Co., London and New York, 1893. As stated in the preface, this essay is based wholly on the various volumes of evidence published by the Royal Commission on Mining Royalties of Great Britain; and the royalties referred to are chiefly those paid to the owners of coal mines. The relation of the fee-owner to the lessee, that of royalties to strikes and wages, and their effect on competition with other countries, together with many kindred subjects, are discussed from the English standpoint. Although not directly appertaining to this country, the volume is interesting to the student of labor questions so far as they affect the miner, and gives a concise view of how such

questions are considered in England where so much more experience has been acquired than in America. H. V. W.

On the Origin of certain Novaculites and Quartzites. By FRANK RUTLEY. (Quart. Jour. Geol. Soc., vol. L, pp. 377-392, pl. 19, Aug., 1894.) The author shows the possibility of the derivation of some fine-grained quartzites and of the novaculites of Arkansas, so well known through Mr. L. S. Griswold's "Whetstones and Novaculites of Arkansas," from limestones by siliceous replacement. The irregular and rhomb-shaped cavities in these rocks represent crystals of a rhombohedral carbonate, probably dolomite, and Mr. Rutley regards them as the remains of part of the original rock, in this case the replacement of the carbonate by quartz being not entirely completed. This explanation of the original nature of the novaculite differs from that of Mr. Griswold, who regards the quartz as original. The same or similar apparent replacements of limestone by quartz are seen in other rocks, often of coarser grain than the novaculites. Mr. Rutley thinks that it is needful to separate the rocks termed quartzites into two groups, including in the one indurated sandstones or true quartzites ("detrital quartzites"), and in the other the siliceous replacements of limestones which at times simulate detrital quartzites; the latter can be called "infiltration or metasomatic quartzites." U. S. G.

Willyamite—a New Mineral from Broken Hill. By E. F. PITTMAN. (Records Geol. Survey, N. S. Wales, vol. IV, pt I, pp. 21-22, 1894.) This mineral is a sulph-antimonide of nickel and cobalt, with the formula $CoS_2 . CoSb_2 : NiS_2 . NiSb_2$. It is isometric in crystallization and is very similar in its physical properties to the sulph-antimonide of nickel, ullmannite. Two analyses are given and each shows that nickel and cobalt are present in approximately equal amounts (over 13 per cent.), thus justifying its separation from ullmannite. U. S. G.

Papers and Notes on the Glacial Geology of Great Britain and Ireland. By the late HENRY CARVILL LEWIS; edited from his unpublished MSS. by HENRY W. CROSSKEY. Pages lxxxi, 469, 8vo, with ten maps, and 83 illustrations in the text. (London and New York: Longmans, Green, and Co., 1894.) This magnificent volume is the fulfillment by Mrs. Lewis of her husband's dying request, that the notes of his glacial observations in Ireland and Great Britain should be published, with the aid, in editorial revision, of his friend, Rev. H. W. Crosskey, who also has since died. (For a biographical sketch of Prof. Lewis, with a review and a bibliography of his scientific work, see the AMERICAN GEOLOGIST, vol. II, pp. 371-379, with portrait, Dec., 1888; and for an obituary notice of Dr. Crosskey, vol. XIII, p. 75, Jan., 1894.) The work has been very carefully edited and places on record for all students of glacial geology the observations and opinions of a most enthusiastic, industrious and successful investigator in that field, where he reaped much and well, although taken from us while yet his plans and hopes were opening with promise of more abundant fruitage after years of further exploration. Attempting to state very concisely some of the chief points in which

Carvill Lewis contributed to more full and true interpretation of the drift formations of Britain, in the light of his previous work in the United States, we note the substitution of ice transportation instead of marine submergence to account for the drift with fragments of many species of sea shells at great hights on Moel Tryfaen and in other localities; exact tracing of the boundaries of the glaciation; the recognition of many areas of ice accumulation and dispersal of boulders; that the Scandinavian ice-sheet extended to England, becoming confluent with the British ice-fields; doubt of interglacial epochs; and the discrimination of till formed beneath the ice, moraines on its margin, and boulder-clay, supposed to have been borne by floe and berg ice beyond the border of the ice-sheets on the surface of large extra-morainic lakes. The whole work will be of great value in stimulating further investigations of the many and difficult questions which still remain to be altogether convincingly answered, so that at length a general unanimity of view shall be reached concerning the origin of the glacial deposits and the causes of glaciation in the British Isles and in all other drift-bearing regions. W. U.

The Mineral Resources of the United States, Calendar year 1893. DAVID T. DAY. Pages vii, 799; Washington, 1894. (U. S. Geol. Survey). This volume appears with unusual promptness, probably under the stimulus of competition with "The Mineral Industry," published by the Scientific Publishing Co., of New York, of which a notice appeared in the last number of the GEOLOGIST. This is, in the main, of the same character and scope as the nine preceding reports from this department of the survey. The statistics which it presents are obtained from the most reliable sources, and the various mining products are reviewed separately by statistical experts. The chapters on petroleum, natural gas and asphaltum are especially full and valuable. N. H. W.

RECENT PUBLICATIONS

I. *Government and State Reports.*

Pennsylvania Geological Survey, 1893, Atlas Summary Final Report, contains: Maps of the state, bituminous coal mines and quarries, Lebanon, Bucks and Montgomery counties.

Pennsylvania Geological Survey, 1893, Atlas contains: Geological maps of Schuylkill, Carbon, Berks and Dauphin counties; topographical map of the Blue mountain at Port Clinton.

Annual Report of the Smithsonian Institution, for 1892, contains: The relation of biology to geological investigation. A series of essays discussing the nature and scientific uses of fossil remains and the necessity for their systematic collection and permanent conservation in public museums, Charles A. White.

U. S. Geological Survey. Mineral resources of the United States, 1893, by David T. Day; 1894, 8vo, pp. vii, 799.

II. Proceedings of Scientific Societies.

Proceedings of the Academy of Natural Sciences of Philadelphia, 1894, pt. 1, contains: Observations on the geology of adjacent parts of Oklahoma and northwest Texas, E. D. Cope: Re-exploration of Hartman's cave, near Stroudsburg, Pa., 1893, H. C. Mercer: Volcanic products from the Hawaiian islands, E. Goldsmith.

The Journal of the Cincinnati Society of Natural History, vol. 17, No. 1, April, 1894, contains: New species of fossils from the Hudson River group and remarks upon others, S. A. Miller and C. L. Faber: The petrified forest of Arizona, S. A. Miller: The granites of Cecil county in northeastern Maryland, G. P. Grimsley.

Proceedings of the Alabama Industrial and Scientific Society, vol. 4, No. 1, 1894, contains. Analysis of limestones and dolomites of the Birmingham Alabama district, C. A. Meissner: On the phosphate rock of Tennessee, W. B. Phillips.

Proc. and Trans. Nova Scotian Inst. of Sci., 2nd ser., vol. 1, pt. 3, contains: Notes on the Miocene Tertiary rocks of the Cypress hills, Northwest Territory of Canada, T. C. Weston: The Pictou coal field—a geological revision, H. S. Poole.

Proc. of the Iowa Acad. of Sciences, for 1893, vol. 1, pt. 4, 1894, contains: On the geological position of *Bennettites dacotensis* Macbride, with remarks on the stratigraphy of the region in which the species was discovered, Samuel Calvin: Notes on the lower strata of the Devonian series in Iowa, W. H. Norton: Cretaceous formations of northwestern Iowa, C. R. Keyes; Derivation of the Unione fauna of the Northwest, C. R. Keyes; Process of formation of certain quartzites, C. R. Keyes: Origin of the present drainage system of Warren county, J. L. Tilton: Structure of the Mystic coal basin, H. F. Bain: Sigourney deep well, H. F. Bain: Southern extension of the Cretaceous in Iowa, E. H. Lonsdale: Topography of the granite and porphpry region of Missouri, E. H. Lonsdale; Occurrence of zinc in northeastern Iowa, A. G. Leonard: Satin spar from Dubuque, A. G. Leonard: Occurrence in Iowa of fossiliferous concretions similar to those of Mazon creek, A. C. Spenser; Evidences of disturbance during the deposition of the Burlington limestones, F. M. Fultz; Coal Measures in Poweshiek county, A. J. Jones: *Cardiocarpus* in Iowa, A. J. Jones; North American cycads, T. H. M'Bride.

III. Papers in Scientific Journals.

The Journal of Geology, vol. 2, No. 4, May-June, 1894, contains: The Norwegian coast plain, Hans Reusch: Glacial cañons, W J McGee Fossil plants as an aid to geology, F. H. Knowlton: Wave-like progress of an epeirogenic uplift, Warren Upham: The occurrence of Algonkian rocks in Vermont and the evidence for their subdivision, C. L. Whittle: Summary of Pre-Cambrian North American literature, C. R. Van Hise.

The Journal of Geology, vol. 2, No. 5, July-Aug., 1894, contains: The

origin of the oldest fossils and the discovery of the bottom of the ocean, W. K. Brooks; The Amazonian Upper Carboniferous fauna O. A. Derby; Geological surveys of Ohio, Edward Orton; Proposed genetic classification of Pleistocene glacial formations, T. C. Chamberlin.

The American Journal of Science, III, vol. 48, No. 1, July, 1894, contains: Occurrence of a large area of nepheline syenite in the township of Dungannon, Ontario, F. D. Adams; Nepheline, sodalite and orthoclase from the nepheline syenite of Dungannon, Ontario, B. J. Harrington; Tertiary changes in the drainage of southwestern Virginia, M. R. Campbell; Upper Vicksburg Eocene and the Chattahoochee Miocene of southwest Georgia and adjacent Florida, A. F. Foerste; Gabbros in the southwest Adirondack region, C. H. Smyth, Jr.; Footprints of vertebrates in the Coal Measures of Kansas, O. C. Marsh; Typical Ornithopoda of the American Jurassic, O. C. Marsh; Eastern division of the Miohippus beds, with notes on some of the characteristeric fossils, O. C. Marsh.

The American Journal of Science, III, vol. 48, No. 2, Aug., 1894, contains: Certain astronomical conditions favorable to glaciation, G. F. Becker; Mineralogical notes, S. L. Penfield; Alunite from Red Mountain, Ouray county, Colorado, E. B. Hurlburt; Mineralogical notes, S. L. Penfield and D. A. Kreider; Carboniferous fossils in the Norfolk county basin, J. B. Woodworth; The stratigraphic position of the Thomson slates, J. E. Spurr; Miocene Artiodactyles from the eastern Miohippus beds, O. C. Marsh.

The School of Mines Quarterly, July, 1894, contains: The optical recognition and economic importance of the common minerals found in building stones, L. McI. Luquer; On the occurrence of Cretaceous clays at Northport, L. I., Heinrich Ries.

IV. Excerpts and Individual Publications.

On some new forms of wollastonite from New York state, Heinrich Ries. Trans. N. Y. Acad. Sci., vol. 13, pp. 146-147, 1894.

Note on the petrography of certain basaltic boulders from Thetford, Vt., E. O. Hovey. Trans. N. Y. Acad. Sci., vol. 13, pp. 161-164, 1894.

A comparative study of the chemical behavior of pyrite and marcasite, A. P. Brown. Proc. Amer. Philos. Soc., vol. 33, 1894; pp. 19.

Some New Red horizons, B. S. Lyman. Proc. Amer. Philos. Soc., vol. 33, pp. 192-215, 1894.

The mineral industry, its statistics, technology and trade in the United States and other countries. By Richard P. Rothwell. Pp. i-xl, 1-894; New York, The Scientific Publishing Co., 1894.

Further notes on Cripple creek ores, Richard Pearce. Proc. Colorado Sci. Soc., Apr. 5, 1894; 7 pp.

The sanitary chemical character of some of the artesian waters of Denver, W. C. Strong. Proc. Colorado Sci. Soc., May 7, 1894; 9 pp.

An analysis of jadeite from Mogoung, Burma, O. C. Farrington. Proc. U. S. Nat. Museum, vol. 17, pp. 29-31, 1894.

On the formation of stalactites and gypsum incrustations in caves, G. P. Merrill. Proc. U. S. Nat. Museum, vol. 17, pp. 77-81, pls. 2-5, 1894.

The formation of sandstone concretions, G. P. Merrill. Proc. U. S. Nat. Museum, vol. 17, pp. 88-89, pl. 6, 1894.

Notes on the invertebrate fauna of the Dakota formation, with descriptions of new molluscan forms, C. A. White. Proc. U. S. Nat. Museum, vol. 17, pp. 131-138, pl. 7, 1894.

Ancient myriapods, G. F. Matthew. Canadian Record of Science, pp. 93-99, April, 1894.

Historical sketch of the discovery of mineral deposits in the Lake Superior region, H. V. Winchell. Second Ann. Rept. of the Proc. of the Lake Superior Mining Institute: 46 pp., 1894.

A review of the fossil flora of Alaska, with descriptions of new species, F. H. Knowlton. Proc. U. S. Nat. Museum, vol. 17, pp. 207-240, pl. 9, 1894.

Geology of the Cripple creek gold mining district, Colorado, Whitman Cross. Proc. Colorado Sci. Soc., June 4, 1894: 18 pp.

The ore deposits of Cripple creek, Colorado, R. A. F. Penrose, Jr. Proc. Colorado Sci. Soc., June 4, 1894; 5 pp.

A classification of economic geological deposits based on origin and original structure, W. O. Crosby. Technological Quarterly, vol. 7, pp. 27-48, April, 1894.

The origin of parallel and intersecting joints, W. O. Crosby. Technological Quarterly, vol. 6, pp. 230-236, Oct., 1893.

The new geological cross sections of Keweenaw point, L. L. Hubbard. Second Ann. Rept. of the Proc. of the Lake Superior Mining Institute: 18 pp., 1894.

The hydro-geology of the upper Mississippi valley and of some of the adjoining territory, D. W. Mead. Journ. of the Association of Engineering Societies, vol. 13, No. 7, pp. 330-386, July, 1894.

Description of some Cincinnati fossils, S. A. Miller and C. L. Faber. Journ. of the Cincinnati Soc. of Nat. Hist., vol. 17, No. 3, pp. 137-158, pls. 7 and 8, Oct., 1894.

V. Proceedings of Scientific Laboratories, etc.

The Kansas University Quarterly, vol. 2, No. 1, July, 1894, contains: Vertebrate remains from the lowermost Cretaceous, S. W. Williston; A new turtle from the Benton Cretaceous, S. W. Williston; Notes on *Uintacrinus socialis* Grinnell, B. H. Hill; Restoration of Platygonus, S. W. Williston; A chemical examination of the waters of the Kaw river and its tributaries, E. H. S. Bailey and E. C. Franklin.

CORRESPONDENCE.

Note on the Geological Map of the State of New York. In the "Twelfth Annual Report of the State Geologist for the year 1892," Albany, 1893, we read at p. 28, that in the geological map published in 1842, by the Geological Survey, "no attempt was made to represent the age and relations of certain of the formations on the east side of the Hudson river." On the contrary, all the three thousand copies distrib-

uted represent the age and relations of all the formations on the east side of the Hudson river as "Hudson river group or Lorraine shale" above the "Utica slate," with long bands and isolated patches of Trenton limestone, called on the map "Black River and Birdseye limestone," so the statement is incorrect.

At p. 29 we read: "At a later period, 1844, Prof. Emmons published an agricultural and geological map of the state to accompany his agricultural report. This map was published upon the same base as the original geological map of the state. The coloration was almost precisely the same on all parts of the map west of the Hudson river. From the northern limit of the state and the adjacent part of Vermont, extending along the east side of the Hudson river and crossing to the west side below Rhinebeck, a belt of color was introduced to show the supposed limits of the 'Taconic system' of rocks, although no mention of the name is made nor any indication in the color legend of the map. The map, however, is fully described on page 361 of volume I of the 'Agriculture of New York.' A description and discussion of the rocks of the Taconic system and of its individual members occupies chapter five, pages 45-112 of the volume. *Since 1844 this map has been the only geological map of the state of New York accessible to the student and to the public.*" The italicising of the last paragraph is mine.

Dr. Emmons, in a published letter (Proceedings American Academy Arts and Sciences, vol. XII, p. 188, Boston) says: "I made and published with my Report while in the Survey of New York a modified map of the state, which showed the extent of the Taconic rocks in New York. The three thousand copies were stolen or destroyed by persons unknown, so that they were never issued with the proper volume." So, instead of being *accessible*, the geological map showing the extent of the Taconic system in New York was *inaccessible*, even to its author, professor Emmons. Lyell, de Verneuil, Agassiz, colonel Jewett, Barrande, etc., never saw it. No student of the geology of New York ever saw that map until about 1877, when a few mutilated copies began to be distributed by the state librarian at Albany.

Instead of being accessible to the student and to the public, as it is claimed, the map of 1844, paid for by the State, disappeared mysteriously until 1877, during a period of thirty-three years: and during all that time "the only geological map of the state of New York accessible to the student and to the public" was the geological map of 1842, on which all the strata containing the primordial fauna are placed above the Utica slate, that is to say, above the second fauna.

Mr. James Hall, the state geologist and state paleontologist, adds, at p. 29: "This *agricultural and geological* map of Dr. Emmons, following so soon after the publication of the state map accompanying the reports of the four geological districts, doubtless prevented any immediate effort to secure the means of preparing and publishing a more accurate geological map of the state." How a map unknown and absolutely inaccessible may have prevented to prepare and publish a more accurate geological map of the state of New York is a material impossibility. If an-

other map has not yet been published, notwithstanding that several times one has been announced as being on the point of being issued, it is simply because the state geologist is at a loss how to deal with his previous opinion of the non-existence of the 25,000 feet of strata of the Taconic system: for even now, notwithstanding all "our accurate knowledge of this region," and "that at the present time comparatively little remains to be done to complete the work" (*loc. cit.*, p. 31), he knows less about all the strata east of the Hudson river than Dr. Emmons did fifty years ago.

Cambridge, Mass., June 24, 1894. JULES MARCOU.

THE SIXTH SESSION OF THE INTERNATIONAL CONGRESS OF GEOLOGISTS. The excursions which were announced for the two weeks preceding the opening of the congress were carried through with a fair number of participants. The trip over the Jura, managed by Prof. Golliez, with the assistance of some of his colleagues, began on August 15, Wednesday, at Geneva, in somewhat inauspicious weather, the first expedition being up the Grand Salève, the largest mountain near Geneva, from which an exceedingly beautiful view of the Mont Blanc series can be had and on which an exceedingly bad luncheon is obtained at the restaurant of the *Treize Arbres*. The weather was rainy and cold and no view was obtainable, though there was no lack of enthusiastic travellers, including one woman. In the evening the president of the council of the canton of Geneva and Colonel Turitini, the mayor of the city, received at a banquet the proposed participants in the congress and their wives. That is to say, the wives were invited, and under the impression that others were to be present, one of these ladies attended, but was alone, to her great mortification.

The guests of this august invitation were not remarkable for any particular style of dress. Some had dark coats, but the majority had light colored suits and boots which were singularly dusty, considering the amount of rain which had fallen. The hosts, however, knew what was due to the respect of themselves and their guests, and their bearing was irreproachable.

Their idea of the speaking part of a dinner was, however, slightly different from that of other parts of the world. After the addresses of welcome had been made by the governor and the mayor, the field was left free to anyone who chose to occupy it without invitation. The old Carl Vogt availed himself of this privilege and made a violent intransigeant speech, taken good humoredly by the hosts. The room was the foyer of the Geneva theater, and one of the most beautiful of its kind in Europe, having much in common with that of the Grand Opera in Paris.

The next day the party of Jura students started off on their trip, for which they had beautiful weather. A few days later a similar dinner was given by the authorities of the canton of Vaud and the city of Lausanne, the residence of the chairman of the committee on organization and the president of this session, E. Renevier. This was given in the modest dining room of the café of the theater and was in all respects less imposing than the initial dinner at Geneva.

Nevertheless the hosts showed appreciation of the objects of the congress and a perfect hospitality.

The congress proper was opened at 9 a. m., Tuesday, Aug. 28, in the council hall of the Polytechnikum, of Zürich. The published *procès verbaux* of the sittings of the council lack the local coloring which would explain how the propositions were accepted. The session was opened with Renevier, president of the committee of organization, in the chair. He proposed to call over the names of the different countries, and asked all the members from those countries to give their names. This very clumsy method resulted in the list first given on the *procès verbal.* On proceeding to the choice of president of the congress, Golliez named Renevier, who at first stated that he ought not to be expected to ask for the vote for himself and immediately thereafter gave thanks for his election without any vote at all.

This was the keynote to the subsequent proceedings, which included the reading of a list of representatives of different countries, selected by the committee on organization, as vice presidents. The first obstacle it encountered was from Señor Cortazar, who naturally objected to having Spain and Portugal lumped together *and represented by the Portuguese colonel Delgado.* This objection being sustained or at least not opposed, Señor Cortazar was named vice president from Spain and Col. Delgado from Portugal.

The next country, alphabetically, was the United States. M. Renevier declared that there were two delegates from the U. S. Geological Survey present, and that, one of them having declined the nomination, he asked the council to recommend the other, Mr. Lester F. Ward, as the vice president representing the United States. There were thirteen geologists present from the United States. The extraordinary principle was then announced that a subordinate department of a government said to transact a certain kind of work can, without the knowledge or consent of that government, send two representatives to a congress of experts in that kind of work and can decide between themselves, without reference to the other representatives from the United States, which of the two shall be the representative of the nation from which he came. This question is entirely independent of the character of the nominee and nothing herein contained is intended to reflect on the suitability of the appointment of Mr. Ward, but the principle is vicious and entirely subversive of those on which the congress is founded. Suppose, for instance, the architect of the capitol at Washington chose to send two of his salaried subordinates to an international congress of architects, and that these should decide between themselves, to the exclusion of any or all architects who might have formed integral parts of past congresses, who should represent their country. This piece of "diplomacy" is simply a notice served to the geological world that henceforth the congress is simply to be the creature of the official bureaus of the different countries, some of whose chiefs, having leagued together at first to strangle it, without success, are now content to use it to serve their own purposes.

The secretaries and treasurer having been chosen without opposition, the council proceeded to the order of the day.

Two former presidents, Capellini and Beyrich, being present, the question which should open the session was postponed till the following day.

The president then brought up the question of what language should be employed, and based upon the action of the last council of the congress in Washington the proposal that German should be admitted equally with French as the language of the congress. M. Renevier, as presiding officer, distinguished himself in the discussion by continually misstating the proposition which was submitted to vote, and finally declaring adopted what he pleased, not at all what was decided. Thus the final form of the proposition was that in all official statements or discussions of routine work French should be used, or a French translation of what was said shall be offered, but that German should be admitted for scientific expositions.

The following sections were then created and their officers elected by the council:

SECTION I. *Géophysique, Géotektonique, Géologie générale.* President, A. de Lapparent, France; vice president, T. McK. Hughes, England.

SECTION II. *Stratigraphie et Paléontologie.* President, Albert Gaudry, France; vice president, K. A. von Zittel, Germany.

SECTION III. *Petrographie et Mineralogie.* President, Michel-Levy, France; vice president, P. Groth, Germany.

SECTION IV. *Géologie appliquée.* President, Hauchecorne, Germany; vice president, Posepny, Austro-Hungary.

Wednesday, Aug. 29, 1894.

The first general session of the congress was held in the aula of the magnificent école scolaire for females. It is in the upper story, a very fine room, showing the rafters, and having decorations of fruits running along the ridge and extending in two arms to reach it from each gable end of the building. Behind the desk of the chairman, where it was of light wood and covered with gray, coarse drapery, is a large map of the region on a scale of 1:25,000, to illustrate the paper of Prof. Heim later. A fine longitudinal section of the Zürich lake bed on a scale of 1: 125,000 lineal and 1:25,000 vertical is displayed on the east wall, while on the west (the right of the presiding officer's desk) is a section across Zürich lake on a scale of 1:2,000 linear and 1:1,000 altitude. At the hour of opening, 2 p. m., there were about 100 persons present.

Capellini, taking the chair, reported the presidents, vice presidents, and secretaries of the congress, and the presidents and vice presidents of the sections. M. Capellini then yields the chair to Renevier, the president, who makes an address in which he says he is penetrated by two thoughts, the one of gratitude for the honor conferred on him, and the other of his insufficiency. He is sure he owes this honor to his regular attendance at the meetings of the congress. He was very much astonished when the cable informed him, three years ago, that Switzerland had been chosen as the site of the next congress, and he was at

first somewhat intimidated, but the little country has done its best. It has laid more than usual stress upon the excursions, and it hopes that the warmth of the reception may make amends for what may seem lacking. Since the first congress at Paris in 1878, many eminent geologists like Sterry Hunt, Sella, Newberry, and recently, G. H. Williams, have died. The primary object of the congress was uniformity, but it was pushed too far, and the result was a protest on the part of its Anglo-Saxon members, and the reaction in turn has gone too far, and thrown the opposition entirely over the saddle. We should seek to unify the language and the methods of the science only, and thus we shall not do injury to the science. By teaching a rational and not a traditional geology, we shall by degrees attain the end sought.

The president then introduced M. Schenck, the member of the federal council, who addressed a welcome to the congress in a most extraordinarily theatrical manner. Learning that this session of the congress was to be held here, the federal council determined that it was an international duty to entertain their guests. Everything possible has been done to make the members of the congress feel at home. He greeted the members in the name of the Bundesrath. Their labors were not confined to cabinets and laboratories, but extended over a space as wide as the world. While this little country cannot offer the wonderful objects of the United States, yet for a small land there was much to interest geologists. There is a little salt, a little iron ore; but no quick—nor commercial—silver is found here. [Laughter.] The land is geologically rich, but in a mining sense poor. You are not here to look at the outside but the inside of the land. Allow me to say that of all human industries and occupations geology is the noblest. What the earth has to do in space geology teaches, and how in the changes of ages it came to occupy its present form and situation. From its teachings we learn the infinite smallness of man. Wonderful is the work which geology has performed, but there is many a riddle yet unsolved. Nothing can so tend to solve these as a meeting of so many able men. May the sixth session of the congress do much toward this end, and may Switzerland be remembered as the place of its labors. [Applause.]

President Renevier then reported the decision of the council in regard to language, as follows:

1. La langue officielle est le francais.—Toutes les affaires administratives se feront en francais. Dans le cas où un exposé ne pourra être fait en francais, il en sera donné une traduction.

2. Les communications scientifiques dans les assemblées générales, et dans les sections, pourront êtres faites en francais et en allemand. Si d'autres langues interviennent, il sera donné, de ces communications, un petit résumé francais comme traduction.

The president then introduced Prof. Suess, who addressed the congress on "conformation of surface by horizontal forces." The speaker said that it had been many years since he had addressed a public assembly in Zurich on this subject, which had been one claiming his at tention for many years. A brief digest of the substance of this paper

from the pen of its author, has been furnished for the AMERICAN GEOLOGIST, and will be used at a future writing. The paper was illustrated by maps of the mountain systems of Asia and Europe. The gist of the paper was that the Carpathians and the Ural range were modeled by horizontal movements, unlike in direction but similar in character to those which had exercised a change in Europe when the Alps and the Pyrenees were involved. A great horizontal movement in the north of Scotland is indicated before the Devonian age. He summed up a most interesting memoir by declaring that what we call deformation is really conformation of the crust of the earth and is but a step in the gradual progress which is towards a final contour far from being reached yet. [Applause.]

Prof. Heim then gave a very clear statement of the geology in the neighborhood of Zürich, declaring his old professor, A. Escher, whose bust overlooked the scene, was right when he declared in 1846 (?) that Zürich is built on a moraine, and that the hills or mountains in its neighborhood are moraine phenomena. The key to this geology is the erosion of the Molasse of Uetliberg and Zürichberg (lower Miocene) and the invasion of this depression by glacial drift. On the summits of the mountains near the town over 60 meters of moraine covers the Molasse in place. The best arable lands are found on the upper moraine. The strongest springs are found in the lower *grund moraine* and are fed by water which has trickled through the upper moraine. The Zürich lake bottom was not ploughed out by glacial action, because (amongst many other reasons given) there are islands at one end of it with a depth of 120 meters of water between them, and, by reason of the direction from which the glacier must have come, they could not have remained had a great force been employed to dig out the lake bottom. Nor can the basin be explained by a fault or crack, because the strata of the Molasse on the two sides give evidence against any dislocation. The basin is due to a depression or sinking of the strata on the end nearest to the Alps and is doubtless connected with the sinking of the entire Alps system. There are also clearly marked three separate glacial epochs.

This lecture commenced with a eulogy of the speaker's former professor (Escher) and of a young pupil of his named Wettstein, who lost his life by a fall in the mountains. Both of them were said to have contributed much to the clear understanding of the geology of Zürich.

In the evening the restaurant of the Zürichhorn, situated on the east bank of the lake and about a kilometer from Zürich, was indicated as a place of informal meeting for the purpose of dining, and most of the members of the congress went there and chatted till 9 or 10 o'clock, returning either on foot, in the tram car, or in the boat.

Thursday, Aug. 30, 1894.

The council met at 8 o'clock in the Polytechnikum. The president offered the compte-rendu of the previous session, and was about to withdraw it as accepted, before it was discussed, when Sir Archibald Geikie moved an amendment to the effect that the rule about language applies

only to the Zürich session. It was declared by the president approved.

An invitation from the Geographical Society of Lisbon was received, inviting the congress to meet there in the year 1897, when the discovery of a route to the Indies by Vasco da Gama will be celebrated. The president remarked that the council at Washington had promised that the next congress after the present one should go to Russia. Dewalque wanted to know how one congress could fix the places of the succeeding two. Renevier replied that of course this congress can ratify a decision of the preceding congress. Col. Delgado, of Portugal, said that the offer was not from the Government of Portugal, which would have communicated any such offer through him, whereas he, being absent when the communication was sent, knew nothing about it.

Renevier asked what to do in the case of a so-called geologist who had wished to join the pedestrian tour of Heim and was told that he was too late, as others had been refused, and then wanted his cotisation money back. The council, rather staggered that such a petty matter should be brought to its notice, murmured various things, and the president stated that he should inform the person that the proposition was inadmissible, and then added in an audible tone to Prof. Heim, "I would not take him anyhow."

The eternal and unanswered proposition of the marquis de Gregorio to found an international geological journal, was taken up and played with for a while, being finally referred to the bibliographical committee. It is strange that the marquis, who has seen this project of his similarly treated for nine years, beginning at the congress of Berlin, is the only member of the congress who fails to note its amusing features, and actually seems to believe that perhaps his grandchildren may see it adopted. Naive marquis!

Professor Heim inquired whether the work sent to Bologna in competition for the prize offered by the king of Italy, in 1881, is the property of the congress or of the university of Bologna. Capellini said the funds were given by the king and that the work should remain in Italy, especially as there is no place of deposit owned by the congress for taking care of such objects. Further discussion was postponed and the meeting was adjourned.

The several sections met in the halls provided for them and papers were presented as follows:

SECTION I.—GEOLOGIE GENERALE.

Prince Roland Bonaparte.—Periodic variations of French glaciers.

Marshall Hall (read).—Glaciers of New Zealand.

Van Calker.—Investigation of erratics.

St. Meunier.—Geological energy attributed to ancient glaciers.

Warren Upham (read).—The Quaternary era and its divisions.

Charles Tardy.—Perturbations of the magnetic field.

Albrecht Penck.—The last dislocation of the Alps.

Rothpletz.—Failles de recouvrement.

Gräff.—Peculiar contact relations between the crystalline nucleus and the sedimentary covering.

F. A. Forel.—Propositions relative to the variations of glaciers throughout the world.

SECTION II.—STRATIGRAPHIE ET PALEONTOLOGIE.

Sacco.—Classification of the Tertiary terranes of Europe.
Ch. Mayer-Eymar.—Tertiary terranes of Switzerland.
G. Böhm.—Age des niveaux à Rudistes de la Venetie.
Rollier.—The Malm of the Jura and of the Randen.
Wöhrmann.—Upper limit of the Muschelkalk.
E. Hull.—Geology of Arabia Petræa and Palestine.
Mercerat.—Geology of Patagonia.
Renerier.—Formations of Facies.
Winchell (read).—L'extension de l'ouest du système Taconique.
Pavlow.—The Neocomian of the northern type.
Gregorio.—Nomenclature of parts of shells of gasteropods and pelecypods.
Stefanescu.—The fossil camel in Roumania.
Gregorio.—Some remarks on the order and method of geological works.
W. Kilian.—On the limit of the Jurassic and Cretaceous in the Alps and Jura.
E. Haug.—On the discovery by Caralpe of ammonées in the Permian of the Pyrenees.

SECTION III.—MINERALOGIE ET PETROGRAPHIE.

Lepsius.—Crystalline and metamorphic rocks of Greece.
Högbom.—Effects of contact of Nepheline Syenite of Sweden.
P. Groth.—Description of an apparatus for the graphic determination of the directions of vibration in any thin sections of biaxial crystals.
Viola.—On the Diabases and Gabbro rocks in the Basilicata (lower Italy).
Duparc.—The crystalline eruptive and metamorphic rocks in the first Alpine zone.
Schmidt.—The crystalline rocks of Switzerland.

SECTION IV.—GEOLOGIE APPLIQUEE.

Posepny.—The relations between industry and geology.
J. H. L. Vogt.—Occurrence of ores through processes of magmatic differentiation.
——— The occurrence of carbonic acid in the Rhine region.

An informal midday meal was had from 12 to 3, at the Plattengarten and an equally informal dinner in the evening in the Tonhalle restaurant, which is entirely enclosed in the Industrial Exhibition of the canton now being held here.

Following are partial minutes of the remaining sessions of the council and of the general meetings of the congress.

The hour of meeting for the council was 8 a. m., and that of the general assembly 9 a. m. Those who make no boast of their early hours were to a large extent on time: but those, including the president, whose devotion to science and taste for primitive simplicity raise them above

their colleagues, were to a great extent late. This was perhaps the reason why the business was conducted without that full discussion and opportunity for deliberation to which the Anglo-Saxon element is accustomed.

The French, who are the most systematic people in the world in spite of their excitability, have their own way of dealing with legislative and judicial assemblies. We consider their methods somewhat arbitrary, especially in the latter class where the judge interrogates the accused, and in the course of his remarks attributes to him a motive and a complete chain of acts before any proof of either has been produced. Still, this tendency is the result of the French desire to "trancher" the complication, to cut the Gordian knot instead of trying to untie it: and it must be said that generally the "judge" has a righteous cause, and generally justice is meted out to the criminal more rapidly than it would be under English and American laws.

In parliamentary debate the French method is also different from that expounded in Cushing's Manual, Robert's Rules of Order, etc., but in the main, up to the moment when the presiding officer puts on his hat as a result of too much complication or too general infraction of order, everyone has a moderately fair chance to be heard. The rules applied by M. Renevier, however, were of the most arbitrary character and seemed to proceed from his desire to accomplish some, to him, desirable end. Thus, when the council was called together at 8:20 or 8:25 and the official minutes of the meeting were distributed among the members, they were declared adopted before anyone had an opportunity to read them, in default of any specific objection. It is true that a member of the council interposed to prevent the arbitrary subversion of the fundamental laws of the congress adopted at the Bologna session, making French the official language, and requiring communications presented in other languages to be résuméed in French, from applying to any but the Zürich session; but as a rule the statements which appeared in the report remained there, though a careful examination would have doubtless led to many corrections.

A most extraordinary proposition was made by the president that the minutes of the assemblée générale could be approved by the council and adopted, without giving the opportunity to those members of the congress who were not in the council to modify or object. This proposition was opposed by nearly half the members of the council, but was carried by a majority of two votes.

Another matter came up which could not but greatly astonish the members. At the séance of the congress held in Bologna in 1881, Prof. Capellini induced the king of Italy to offer a prize of about 6,000 francs for the best competitive treatise on certain geological subjects. A number of works were forwarded, and a committee was appointed to inspect them, which finally reported that in its judgment none had fulfilled the conditions which would entitle the competitor to the first prize. Nevertheless a prize of about 1,100 francs was awarded to the contribution adjudged the best, and on opening the envelope containing the name of

the contributor it was found to be Prof. Heim, of Zürich; and the prize was duly sent to and acknowledged by him. Shortly afterward Prof. Heim requested Prof. Capellini to loan him the manuscript of his work (which, by the way, appeared in the Bologna volume), promising to return it. Prof. Capellini, relying upon the perfect good faith of his colleague, at once took the manuscript from the archives and forwarded it. As time rolled by without its return, Capellini wrote to Heim about it and received assurance that it would be sent in a few weeks. Thirteen years have elapsed and the manuscript is still here, and what is more remarkable, Prof. Heim asked the council of the congress to declare whose property it is. Comment is unnecessary. M. de Lapparent extricated the council from an exceedingly difficult position by proposing a resolution, which was fortunately adopted, that the council could not interfere in a matter which concerned the competitors for a prize offered by the Italian king.

M. Forel proposed the nomination of a committee to study the changes which occur in glaciers. After some discussion the following were appointed on this committee, with power to add to itself others from Italy, Norway and Russia, viz: RICHTER, Austria; FINTSWALDER, Germany; REID, United States; BONAPARTE, France; HALL, Great Britain; FOREL, Switzerland. Prince Roland Bonaparte offered to bear the costs of this committee, which was received with applause by the council.

M. van Calker, of Holland, had the idea of appointing a committee to study the distribution of erratics, and there was some friction as to whether the same commission should undertake both subjects. It was finally decided to adopt the glacial committee and to recommend the members of the congress to organize a society for the study of erratics.

It was mentioned previously that when the bureau of the congress was under contemplation the president, M. Renevier, stated that there were only two "delegates" from the United States, namely, those sent by the U. S. Geological Survey. As one of them refused to serve as vice president and recommended that the other be elected vice president to represent the United States, M. Renevier recommended this course to the council and it was adopted. The only member from the United States present judged it inopportune at that time to protest against the principle thus tacitly admitted, more especially as the nominee, Mr. Lester F. Ward, was eminently worthy of the honor. He conceived it to be his duty, however, not to allow such a subversion of the fundamental objects of the congress to pass unnoticed, and consequently presented to the council the following proposition for determination and report by the bureau in time to govern the constitution of the next congress:

"The bureau of the congress will consider the following questions and will reach a decision in time to apply it to the organization of the next congress:

"1. To what extent does the congress recognize the right of governmental bureaus as such, of societies, or of any kind of organizations, to send representatives to the congress?

"2. Within what limitations does the congress recognize the right of

such representatives, or of only a portion of the members of the congress coming from the same country, to choose who shall be the vice president representing their country, or to take any other steps (in the name of their country) without consultation with all their countrymen members of the congress?"

The words in parenthesis do not appear in the printed procès verbal, but the omission will doubtless be corrected in the official volume.

A warm friend of this proposal, who has great influence in the council, proposed that it should be settled by the next day; but the proposer preferred that it be left to the careful deliberation of the bureau, insisting only that it be not pigeon-holed, which from its terms it cannot be, since the bureau, which consists of that part of the present council who are officers, has engaged itself unanimously to consider it and apply it to the next organization.

The abuse is a flagrant one. If there is an object above all others for the congress to fulfill, it is to open its doors equally to all geologists without distinction or favor. Should the congress decide that those who hold positions in the departments of the various governments enjoy exclusive privileges, and, amongst others, that of constituting their permanent organization which keeps the congress alive between its regular sessions, then it is a proclamation to the world that this body has been transformed into a servant of officialism. It is simply an international geological survey trust, whose mission is to extenuate the errors and preserve the power of its constituent geological survey directors. It is merely a play upon words to call it an organization of nations, for the representatives of the nations have nothing to do with the appointments and for the most part are quite in ignorance of the persons who act in their name. It is a means of disposing of the always troublesome "independent geologists" who owe allegiance only to their science, and who are taxed at home to provide the salaries of those who would thus deny them equal rights in an international institution. These independent geologists in all countries are an important factor in the establishment of facts, and, apart from the fact that they usually form the large majority of those whose work is geological, they act as a check upon hasty conclusions and imperfect work. But it is better that the bureau should have full time and liberty to declare itself than that any hasty conclusions on the questions submitted to it should be made.

If, as some of the more influential and older members of the congress think, the congress has been diverted from its original excellent purpose and has fallen into the hands of those who, if they cannot use it for their own selfish purposes, intend to destroy it, the sooner this intention is apparent the better. If, on the contrary, it is to be the highest tribunal of appeal on purely scientific matters, if it is to be outside of the influence of partisans, time servers or even governments, it will admit to its counsels without distinction all who have earned the right to be considered geologists; nor will the decision be embarrassed by the adoption of a rule which would give to every nation represented only one vote. At least all the representatives of each nation would enjoy

equal rights. Let the bureau decide these questions and we shall know what to expect.

M. Karpinsky, of Russia, submits the invitation of the Russian geologists that the congress meet in Russia in 1897, which is adopted. The committee of organization is named, with power to add to its number.

An interesting incident of the second general session of the congress was the good wishes offered to Prof. Beyrich, on behalf of the congress, by Prof. Heim, on the occasion of his eightieth birthday. The good feeling was very hearty and spontaneous, but the recipient seemed somewhat embarrassed by it; perhaps for the reason, which he explained to your correspondent, that he does not attain his eightieth birthday until next year.

The addresses of Suess, von Zittel and Michel-Levy at these general assemblies were very interesting and worthy of the occasion.

The last session of the council but one took place on Saturday morning, when, after the reading of the minutes, Nikitin (Russia), Oldham (English India), Penck (Germany and Austria), and Sacco (Italy) were added to the committee on bibliography. Gilbert, the president, having resigned, Nikitin was elected president in his place.

The final session of the council (the fifth) was held at the Polytechnikum at 2 p. m., after the final session general at the female seminary.

The nominations of the members of the committee on organization for the next congress in Russia were completed.

The members of a committee were appointed, at the instigation of Michel-Levy, for the unification of the nomenclature of rocks. Following is a partial list of this committee: Knop, Zirkel, Rosenbusch (Germany); Golliez, Hutenmal, Schmidt (Switzerland); Renard, de la Vallée Poussin (Belgium); Behrens, Wichmann (Holland); Macpherson, Gonzalo y Farin (Spain); Bensaude (Portugal); Michel-Levy, Barrois, La Croix (France); Teall, A. Geikie, Judd (England); Brögger (Norway); Zujovic (Roumania); Löwinson-Lessing (Russia); Tietze, Tschermak (Austro-Hungary); Iddings, Cross, Van Hise (United States); Barcena (Mexico).

Dr. Tietze asserted that he was not a petrographer and if retained could only bring general geological knowledge to bear on the subject. He also claimed that the origin of the idea of making an international geological map of Europe was in the Reichsanstalt of Vienna and read a passage from its proceedings anterior to the Bologna session of the congress in corroboration of his point. Hauchecorne claimed that it was made anterior to the session at Paris.

M. Pellati (Italy) proposed (1) that there should be a permanent committee appointed with authority to regulate the affairs of the congress between sessions; (2) the seat of the committee should be Paris; (3) this committee shall consist of all the officers; (4) those contributing 10 francs a year shall be considered members; (5) this committee shall issue a publication which shall be the organ of the congress.

Here a scene occurred which will present a just view of the manner in which president Renevier conducts the business of a deliberative as-

sembly. M. Golliez, general secretary, proposed that a committee consisting of the past presidents *and general secretaries* should be requested to consider and draw up a report to the next congress on the advisability of such a permanent committee being appointed. M. de Lapparent drew the attention of the council to the fact that this was a total subversion of the idea of the congress and its transformation into a geological society, and that the council had no authority to take such a step of its own initiative. The president, who could not conceal his strong approval of Golliez's plan, finally declared that he would not permit discussion on the merits of the proposition, but only on the question advanced by M. de Lapparent. Nevertheless he consumed more than half the time in discussing it himself in all its bearings, and finally declared, "We have three propositions before us: that of M. de Lapparent, declaring that the council is incompetent to decide the question (though for my part I do not see that it will be more competent in 1897 than it is now): that of M. Golliez, appointing a committee to examine the question and report at the next congress; and, finally, that of M. Heim, which declares that we shall not consider the subject at all. As Mr. Heim's motion is the most radical, we shall consider it first." It received nine votes. Second, the proposition of M. de Lapparent received eleven votes: and that of M. Golliez only two votes. There were perhaps fourteen members voting in all, and M. de Lapparent's proposition was adopted. In order to be absolutely perfect, Golliez's proposition should have read: All previous presidents whose names commence with an R, and all general secretaries whose last names commence with a G. But imagine the new parliamentary departure, when three contradictory resolutions are entertained at the same time and voted for in succession, some of the voters casting their ballots for two or for all! Thus, by a very narrow majority, another attempt to destroy the congress failed.

While M. Gregorio is speaking on his favorite topic, that of the advantage of having a congressional journal, the president politely roars that the séance is closed, and the members disperse, although the marquis is still on the floor struggling with his temper and his French.

Thus ended the sixth session of the International Congress of Geologists. It was a notable gathering of many eminent men, and an object lesson in the employment of caucus primary methods in the elevated sphere of high science. An impartial judge would probably prefer to revert to the old period of smiling Italian diplomacy, where appearances were preserved while the "machine" worked even more effectively, though not in the direction of suicide.

A word in regard to the collation offered by the town of Zürich to the members of the congress. Uetliberg is a station some 1,200 feet above the town, on the summit of the moraine hills and in a most commanding position. An ordinary railway conducts thither through sinuous courses, the locomotive taking up three loaded cars on a gradient (as the engineer informed me) of about 10 per cent., or more correctly 8 in 100. When we were all there a number of the members followed Prof. Heim in an exciting chase up and down hill in search for outcrops of Decken-

schrotter and other moraine deposits. Some of the Roumanians came back looking as if they had been over the course of a glacier in a sitting position, with the glacier in their laps. We took seats at four long tables, the fifth being reserved for the Burgomeister and the congress dignitaries with many others. The Burgomeister began an interminable speech in which he complimented the science of geology and showed his knowledge of Latin. M. de Lapparent replied in his always happy style, stating, among other things, that the congress was now sixteen years old; that, according to a very general European custom, when a young man who has applied himself diligently to his studies reaches that age he is rewarded by a trip to Switzerland; and this the congress was now taking.

The collation was of cold meats with jelly, and the wine at first on the table was gratuitous. Further refections were charged to the consumer. In the afternoon an excursion of members of the congress and their wives started to make a tour of the lake. As a violent downpour of rain and hail occurred, however, it is to be feared that the pleasure of the trip may have been marred. One of the most vivid electrical storms which your correspondent ever saw, accompanied by hail and rain, occurred during the night. The hail stones struck the Venetian blinds with reports like rifle shots, while the lightning and thunder were incessant.

Prof. Golliez gives in the livret-guide (prepared to explain the geology of the regions visited by the members taking the excursions) certain explanations of a district particularly studied by Prof. Baltz of Berne. The latter has printed a sheet and distributed it to the members, controverting the statements of Golliez. But the language and manner in which this is done gives evidence that the amenities are less considered in certain countries than they are with us. PERSIFOR FRAZER.

Zürich, Sept. 3, 1894.

PERSONAL AND SCIENTIFIC NEWS.

AT THE MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, held in Oxford from August 6th to the 15th, the address of L. Fletcher, president of Section C (Geology), was on recent progress in mineralogy. Forty-three papers were presented in this section. Monday, the 13th, was devoted to Pleistocene geology, which had ten papers. One of these, by E. P. Culverwell, was "An examination of Croll's and Ball's theory of ice ages and genial ages," in which he stated that mathematical investigation proves the inadequacy of the astronomic theory as at present formulated. He therefore ascribed the Glacial period to geographic changes or to variations in the sun's supply of heat. A joint discussion on

the plateau stone implements of Kent, held by Sections C and H (Anthropology), was opened by Prof. Rupert Jones, who agreed with Prestwich that they afford evidence of a great antiquity for man in Britain, "when the physical geography of the Weald was very different from its character to-day." Mr. Whitaker, on the other hand, thought that these recent discoveries and investigations bring "no evidence to connect men with preglacial or even glacial times."

The Geological Survey of India has issued a second edition of its "Manual of the Geology of India," forming a volume of 540 pages, with a general geological map, a special map and sections of the Himalayas, a map of the Indo-Gangetic alluvium, seventeen plates of typical fossils, and twenty-seven figures in the text. This work gives the results of the survey to the present time. It includes the greater part of the first edition, which was prepared by Medlicott and Blanford fifteen years ago, to which Mr. R. D. Oldham, the compiler of this edition, has added largely, wholly rewriting the chapters on the age and origin of the Himalayas and on the geological history of the Indian peninsula.

The two Arctic expeditions of this summer from the United States have returned within the past month. Their chief contributions to geology are the observations on the border of the Greenland ice-sheet by Prof. T. C. Chamberlin, in the Peary relief expedition on the Falcon, and by Prof. G. F. Wright, in the Cook expedition on the Miranda. The former arrived at St. Johns, Newfoundland, Sept. 15th, having coasted along the west side of Greenland, with landings at numerous places and special explorations of the glaciers and ice-sheet on and near Inglefield gulf, in the vicinity of Peary's winter station. Lieut. Peary, with a small party, remains in Greenland for another year, hoping thereby to complete his mapping of its northern coast. The Miranda, on her way north, collided with an iceberg in the strait of Belle Isle, causing delay for repairs in a harbor of Labrador and afterward at St. Johns. Again advancing north, this party first landed for three days' exploration at Sukkertoppen. Shortly after leaving this harbor, the Miranda was disabled by striking on a submerged reef, causing her to return to Sukkertoppen for a further stay of twelve days. After transfer of the scientific party, numbering forty-one, to the Gloucester fishing schooner Rigel, the Miranda, with the Rigel in tow, started on her return to St. Johns, but after steaming about 300 miles was abandoned in Davis strait August 23rd, in a sinking condition, her crew being all transferred to the schooner. Having stopped in Labrador to take twelve others of the Miranda's original party, who had remained there, the Rigel arrived at the port of North Sydney, Cape Breton island, Sept. 5th.

and is covered with houses. Two churches are also built upon it. In some places it has been cut away, but it continues as a prominent feature as far as Clopperton street. Where excavations have been made the composition of the ridge is shown to be of characteristic beach material,—rounded gravel and pebbles with sand. Near its outer end this ridge is about 20 feet above the general level of the town. The altitude of lake Simcoe is stated by Dr. Spencer to be 722 feet above sea level. The shore line in Barrie, measured on the beach ridge where it is crossed in the eastern part of the town by the Penetanguishene road, is about 60 feet above lake Simcoe, or approximately 780 feet above the sea. Westward from the spit the ground is lower and for some distance west of the town it is a rolling sand plain. Between Barrie and Allandale there is a low trough extending westward from the lake. Along the base of the hill south and west of Allandale the beach was found rather lightly developed. We ascended the first point of the hill on the Cookstown road, from which a wide view over the surrounding lowlands was obtained. Toward the west in the trough, which divides the highlands of the north from those on the south, the extension of the beach could be seen for a mile or more; but whether the water at the time of submergence extended clear through the trough to Colwell so as to make an island of the highlands north of it, was not seen. Eastward from Barrie the shore line was found beautifully developed all the way to Orillia. It may be seen plainly from the train nearly all the way. Just east of Barrie the railroad cuts the beach, making a fine cross-section, and then rises to a higher level for a few miles, leaving the beach between it and the lake. Through this stretch it is a finely formed gravel ridge with a lagoon hollow behind it. In some places there are several lower ridges with intervening hollows. But beyond that, for most of the way to Orillia, it is a cut terrace with a low bluff at its back and a gentle boulder slope in front. It is well formed at Oro and Hawkstone. Within a few miles of Orillia the beach passes out of sight in a forest.

Orillia. Along the face of the high bluff back of this place the shore line was found clearly developed as a cut terrace with a few beach ridges at lower levels. It is particularly

well marked just above the main road for two or three miles north of the town. It is nearly as prominent in the town itself, and may be seen to good advantage on West, Coldwater and Penetang streets, and in several other places. Toward the south the ancient coast line becomes deeply indented by a valley, and into this the shore line gradually fades away. During the second visit to this place I drove to McDonald's hill, about two miles northeast of Atherly, a village which is about two miles east of Orillia, on the opposite side of the river. This hill is about 85 feet above the lake and its crest, which is a wide, bouldery beach ridge, extends in a northeast and southwest direction, and appears to have been heavily washed by waves. Extensive excavations have been opened in the western slope of the hill near its top for ballast, and they show its composition to be almost entirely of limestone boulders of small size, and grading from this down to the fineness of coarse sand. The quantity of small boulders or cobbles of a diameter averaging from four to eight inches is enormous. All the material is thoroughly rounded. The hill faces northwestward over lake Couchiching and the valley of the Severn river, toward Georgian bay. This hill is not quite high enough to record the highest beach, and there is no higher ground on that side of the river within a distance of six miles or more. The altitude of the beach in Orillia, measured at the back of the terrace in the town, is about 110 feet above lake Simcoe, or 830 feet above the sea level. Both here and at Barrie we explored the higher ground without finding any evidence of submergence.

Lorneville. In going from Orillia to Lindsay the Algonquin beach was again crossed at a point about a mile and a half west of Lorneville. At this place a series of well formed, but rather low and light sandy beach ridges rests upon an open country, sloping gradually toward the southwest. The upper ridge is about 815 feet above sea level, and appears to mark the upper limit of postglacial submergence.

Midland. At a point about two miles and a half south of this place the highest shore line was found very plainly developed against the north and east face of a high hill, at an altitude of about 820 feet above the sea. Between the town and this locality fragments of beaches were observed in two or

three places, and the terrace itself is flanked below by a very marked boulder pavement. We ascended the hill to an altitude of about 150 feet above the beach, but saw no further evidences of submergence. Marks of submergence are also plain for two or three miles east of Midland. The small lake which lies south of the road, and which has its outlet southward and then northward by a circuitous route, was probably cut off from its former direct connection with Georgian bay by shore drift when the water was at a higher level.

Many impressive evidences of submergence were seen on a drive from Midland to the town of Penetanguishene, which is at the head of another bay about ten miles farther west. In the edge of Midland the road passes through a tract that is covered by an enormous quantity of large boulders, mostly erratics of northern origin, which must have been carried by the ice-sheet across a part of Georgian bay. Half a mile or more beyond this there begins a series of terraces which extend two or three miles along the northwest face of the hill. They are situated upon a very steep slope and are narrow, but they are strongly and clearly formed. At one place there are five of these terraces arranged like steps on the steep hillside. The lower one is much wider than the rest, and is, in fact, a narrow sandy plain. The upper terraces are composed mainly of pretty coarse material. Farther on, the hill east of Penetanguishene rises about to the level of the shore line observed south of Midland, but we did not succeed in finding the beach on the south slope, which was the only side we examined. From the upper edge of the town looking toward the southwest we could see a distinct mark along the face of a high hill about two miles away. This mark appeared to be a terrace and is not far from the level of the beach at Midland.

Thus far all the observations made were within a field formerly explored by Dr. Spencer, although he does not mention observations at any of the points here described.

Parry Sound. From Midland we went to Parry Sound by steamer through the wonderful archipelago which lines the coast of the Georgian bay. The smaller, outer islands are mostly bare, but the larger islands are in some places covered with the coarser kinds of sediments. Hardly anything was

seen, however, which would tend to establish the fact of submergence.

The village of Parry Sound is built upon a gravelly delta deposit which is about 50 feet above the sound. Across the river I ascended the rugged hill back of Parry Harbor to an altitude of about 150 feet, but found no distinct evidence of postglacial submergence. Our exploration, however, was too limited at this place to give much value to this negative result.* From Parry Sound we went by stage 18 miles across the country to Port Cockburn, at the head of lake Joseph. At two or three places evidences of general submergence were seen. On the west side of Horseshoe lake, there are some terraces which are evidently the product of wave action. They were about 60 feet above the lake, and about 210 feet above Georgian bay. About the head of lake Joseph there are some suggestive features about 50 feet above its surface, but none that were distinct and clear. Nor were any noticed on the trip down lakes Joseph and Muskoka.

Gravenhurst. At this place our time was too short to admit of thorough examination. In the upper part of the village, however, there is a wide sandy and gravelly ridge which faces westward over Muskoka lake and is undoubtedly in part the work of waves. But we did not see any evidence which showed whether it is the highest ridge or not. Its altitude is about 825 feet above sea level. In going northward by train we saw abundant evidence of submergence within two to four miles, at levels 75 to 100 feet higher, but the upper limit was not distinctly made out.

Bracebridge. At this place we found magnificent remains of the great submergence. They are of two kinds: one is the product of wave action, and the other of still-water deposition. The latter, especially, is developed on a grand scale. The beaches are clearly defined, and the still-water sediments are fine-bedded or laminated silts and clays in horizontal layers, forming a deposit 75 to 100 feet thick.

Taking the main road northeast from Bracebridge we crossed the river just below the station and climbed the steep ascent of the east bank to the surface of a sandy plain. Within

*I have since learned that Mr. Gilbert had visited Parry Sound and found terraces which we did not see.

a mile, dunes and sandy ridges began to appear. One of these, in a field about 40 rods east of the road, is a long and very evenly formed beach ridge. Farther to the northeast the road crosses a few faint ridges and then ascends a series of three or four low gravelly terraces, which face like steps toward the southwest over the sandy plain. The first road to the right, which follows the seventh and eighth concession line of Macaulay township, leads across a series of ridges of gneiss, with intervening hollows of considerable depth. Across these we drove about three miles to an abandoned farm which appeared to be near the top of a fifth principal ridge. On the east side of the first ridge and near its top there is a large terrace of water-worn gravel and pebbles. Its composition is well shown in a ballast pit. At the top of the third ridge, which is about two and a half miles northeast of Bracebridge, the most marked evidences of wave action were found. The crest of this ridge is flanked on both sides by gravel terraces. The one on the east is small and narrow, and the ground is not well cleared for observation, but the one on the west is much heavier and easier to see. In a lot just south of the road it has the form of a wide, low ridge with a slight depression behind it. North of the road the terrace extends at about the same width, and the farm buildings of Mr. Leeder are built upon it. From the field south of the road the terrace extends southward as a short spit ridge, forming a connection with a rocky ledge, which was formerly a reef with water off its precipitous front 60 to 70 feet deep. Excavations for postholes show the composition of the spit and the terrace in the field to be characteristic beach gravel. This terrace faces southwest over the valley of the Muskoka river, and Muskoka lake and Georgian bay. Its altitude is about 975 feet above sea level. In passing over the other ridges to the eastward we did not discover any evidence of submergence at higher levels. The second ridge, which lies next west of the third, is not so high and did not record the upper limit of wave action. The first ridge lacks only 20 or 25 feet of being as high as the third one, but we saw nothing to show whether the terrace on its east side marks the highest level of submergence or not. Looking eastward from the top of the second ridge, the terrace at Leeder's farm, on the third, is seen to

extend in a great curve around to the north and join the second. From the first ridge the long level of the terrace extending for two or three miles to the north is plainly seen.

Returning to the lower ground, we found that the sandy plain which forms the banks of the river at Bracebridge is the top of a great deposit of silt and clay, and that the town itself is situated upon an eroded slope of this great bed. Several excavations in the streets showed its character very well. The banks along the river are steep and, below the falls, 90 to 100 feet high. In some places this whole depth is composed of the laminated beds. It is plain that the extent of this deposit was once considerably greater than now; for the numerous deep ravines which have been cut into it since the recession of the water show how much has been removed.

We drove also about seven miles southeast, past the falls of the south branch of the Muskoka river, to a point about two miles above. For the first mile the road is over the deeply gullied surface of the silt plain. Then the road passes over a hill, at an altitude of about 90 feet above the railroad station, and on the top of this hill are several well formed beach ridges of water-worn gravel with depressions between them. Beyond this the road descends through a very deep and steep-sided valley which has been cut out of the silt by a small stream. Both sides show the laminated fine sediments to a depth of over 100 feet. The beaches mentioned are on the top of the north bank, and the contact between them and the silt may be seen in the ditch by the roadside. Between this gully and South falls the road passes over some higher ground which is pretty heavily covered with dune sand, and is at about the same level as the sandy tract northeast of Bracebridge, but considerably below the highest beach.

From Bracebridge to Muskoka lake, the Muskoka river is a navigable stream flowing with a sluggish current through a great expanse of swampy flats. After the maximum submergence, during which the upper part of the former estuary of the Muskoka was filled with the silts and clays, the recession of the waters was accompanied by a restored activity of the river, which then commenced the re-excavation of its bed. We have in consequence the level plain of the silts at Bracebridge cut by the narrow, deep gorges of the river and of sev-

eral creeks, and below, toward the lake, the wide flats built up largely with the silt brought down from above.

Huntsville. As it passes northward from Bracebridge the railroad climbs up out of the gorge of the Muskoka river, and toward Huntsville passes over ground mostly at or near the level of the beach at Bracebridge. At several points heavy deposits of water-worn gravel and pebbles are crossed. At its highest point the railroad appeared to pass somewhat above the level of these sediments. But on the descent toward Huntsville the gravels are particularly conspicuous, choking up the beds of all the small streams and forming long, narrow gravel plains. At several points these deposits have been excavated for ballast. At Huntsville station the evidence of postglacial submergence is very clear, although it is not strongly developed. The station is on the east shore of an arm of Vernon lake and its altitude above the sea is 960 feet. A steep hill rises back of the station to a hight of over 350 feet, and along the base of this hill, almost within a stone's throw of the station, the highest shore line is sharply and clearly marked as a cut terrace. Its altitude above the station is about 40 feet. For over half a mile along the western face of this hill the shore line is plain and continuous, and it was easily recognized for about a mile farther each way. At the back of the terrace the old bluff rises ten or fifteen feet more steeply than the general slope of the hill above. I climbed to the top of the hill, starting up opposite Cook's hotel, and reached a point over 300 feet above the shore line, but saw no further evidence of submergence. The top of this hill commands a grand view over most of the country around. Several lakes are in sight at once, Vernon lake toward the northwest, Fairy lake and Peninsula lake toward the east; lake Mary toward the southwest was not in sight, but the water from the other lakes passes down through it and the north branch of the Muskoka river to Bracebridge. The shore line at Huntsville is not in a place exposed to a wide sweep of waters like Georgian bay, but marks the shore of a former sound or long inlet, which reached from the inland valleys to the open water at Bracebridge. The valley is wide and open all the way from the head of Vernon lake. Steamers ply from Huntsville to all these lakes, and by a portage of less than a mile

they connect with the Lake of Bays, which empties into the south branch of the Muskoka river and formed another of the many ancient inlets of this region. The fine bedded silts were found at several places in Huntsville close up to the level of the beach. I have no doubt that this shore line is a part of the highest beach of postglacial submergence and is one with the main beach on the more exposed coast outside.

Burk's Falls. Our observations at this place were somewhat disappointing. We failed to find any distinct beach which might mark the upper limit of submergence. Probably this was because of misinformation with regard to the proper roads to take to reach favorable high ground. Many interesting remains of submergence, however, were observed, nearly all of them belonging to the fine sediment class. The laminated silts and clays of Bracebridge are in some respects equalled, if not excelled, by those at Burk's Falls, where also they attain a depth of about 100 feet. The Maganetawan river has cut a deep ravine through the silt bed, and its little tributaries have cut numerous gullies in the remaining mass. The general appearance of the formation is the same as at Bracebridge. We drove about three miles and a half southeast of Burk's Falls to a point on the hills near Katrine. The cleared farms of that vicinity are mostly on the gullied surface of the silt deposit. At one point the road rises to a level of about 135 feet above the station and cuts a bed of water-worn gravel which may be related to the submergence, but we saw nothing which would establish that fact. Between the village and the station gravel beds were observed in two places resting on the top of the silt. One of these is south of the road near the Presbyterian church, the other is on the opposite side near the top of a low hill. It seems probable that these gravels mark a level not more than 30 or 40 feet below the maximum hight of water during submergence. We also drove about four miles west from the village to an old winter ford of the Maganetawan. The road is mostly at lower levels, and, for the first mile or two, crosses the gullied surface of the silt. Some interesting sections of the deposit were seen here with the laminations beautifully displayed and in several places very much disturbed by faults and folds, which appear to be due to landslides and slippings on the steep sides of the gullies.

The hills about Burk's Falls are high, and if the submergence attained the hight which seems to be indicated by the deposits, the ancient channels were deep, and varied in width from a half mile to three or four miles. Dr. Spencer puts the altitude of the submergence at this place conjecturally at 1,171 feet. Steamers run from Burk's Falls to Ahmic Harbor, 40 miles west, down the Maganetawan, but our limited time did not permit this trip.

Sundridge. This place is situated on the north shore of Stony lake, which empties through Stony creek towards the southwest into the Maganetawan river. The lake is five or six miles wide, and it fills only part of the trough in which it lies. Near the station there are several light terraces and beach ridges of sandy composition; and about a half a mile north there is a heavy glacial ridge, on the south side of which is a tolerably distinct shore line at about 100 feet above the station. On the slope below are several distinct terraces. This beach, like that at Huntsville, might be supposed to be of local origin, but it is also on one of those long inlets which connected with the wider water outside.

South River. At this place we have crossed the divide to the region of the streams which descended the steep slope northward to lake Nipissing. Part of the drive from Sundridge was entirely above the level of the beaches of this vicinity and over unmodified drift. About a mile west of South River a distinct cut terrace was crossed at the foot of a steep hill. But it was so obscured by a heavy forest growth that the character of the ground in that vicinity could not be seen to advantage. There appeared to be a gradual slope, about a quarter of a mile wide, with occasional boulders and an appearance of low ridges. At its edge the road comes out upon a sand plain with dunes, and then descends through the ravine of a small stream. In this ravine the fine-bedded silts and clays again appear, and from this place to the town, half a mile distant, the road passes over the surface of a level sandy plain. Measured from the station at South River the altitude of the cut terrace is about 1,220 feet above sea level. At another point, about two miles south of South River, two terraces are found on a sandy hillside at altitudes of about 1,190 and 1,195 feet above the station, and on another isolated

hill at an altitude of about 1,215 feet. From the top of this last hill there is a wide view over the surrounding country and it could be seen that the flats at South River are continuous through to Stony lake, and they also extend a long way eastward up the valley of South river. In that direction the hills bordering the flats appeared to be terraced at 50 or 60 feet above the flats, agreeing closely with the level of the shore line west of South River station. Half a mile north of the station are Dunbar's falls, where the river was diverted to one side of its former valley and thrown upon a rocky ledge. From this it falls more than 100 feet and has excavated a deep ravine towards the north. It is apparently certain that the whole sandy plain at South River is the surface of a great silt bed. At a point about three miles north of South River the railroad crosses a marsh about two miles wide. This is the top of the grade of the railroad, and its altitude on the profile is given as 1,202 feet. The west side of the swamp is bounded by a great gravel ridge, which looked from the distance like a beach, but which, on close examination, proved to be a glacial moraine. Its summit rises about 80 or 90 feet above the marsh, is very uneven and covered with many pits and hollows. It has been excavated for ballast by the railroad, showing it to be composed of all grades of material from fine sand to large boulders. About half a mile north of the gravel pit the moraine slopes rapidly northward down into the deep ravine of South river, and looking from the edge there may be seen at a distance of three or four miles to the north a very conspicuous shelf which appears as a long horizontal line extending along the east side. This shelf is very close to the level of the beach at South River. and I have no doubt that it represents the highest line of submergence. It was near the mouth of the ravine and was exposed to the northwest over lake Nipissing.

Trout Creek. The high terrace just mentioned must be close to the station of Trout Creek, probably within a mile or two to the south, but it did not appear to be accessible in the short time at our disposal. Our efforts to explore the vicinity of this place were rather unfortunate. We arrived only a little before dark and it began to rain immediately. We drove westward about two miles over a sandy plain to the bridge over South river, where we found a fresh excavation in the

high bank on the east side, which showed a splendid section of the fine-bedded silts and indicated that the whole plain over which we had passed is of that composition. There are also several dunes on the plain. Southeast of the station along the base of the hill there is a cut terrace about 20 feet above the flats. The flats themselves extend about two miles southward to the south end of the long trestle. They are apparently perfectly level, and just under the south end of the trestle there is a terrace in the same relation to them as that near the station, and it is probably a continuation of the same. In September, when I revisited Trout Creek alone, it rained harder than before; but I walked half a mile up the hill to the east and reached a point about 110 feet above the level of the station. At that place there appeared to be a sort of shelf facing the northwest and covered with a great number of boulders of large size. There were so many of them five to six feet or more in diameter that the road had to be crooked about to find a way among them. The altitude of this place is about 1,145 feet above the sea. On the basis of the observations at Sundridge and South River the boulders on the hillside are probably somewhat less than 100 feet below the level of the highest beach. Considering the very exposed position of this hillside, I should expect to find the highest beach strongly developed. From this point the hills at the supposed hight of the shore line extend slightly north of east to the valley of the Ottawa river and also toward the west-southwest 30 or 40 miles. Pawassan, seven miles north of Trout Creek and about 175 feet lower, is also an interesting locality. Besides fragmentary beach ridges of gravel, the silt beds are extensively developed and lie apparently in a more exposed position than usual. Of the other localities farther north, which were visited on these excursions, a separate account has been given in another article,* which is virtually a continuation of this although it was earlier in publication.

*"The Ancient Strait at Nipissing," Bulletin, Geol. Soc. of America, vol. v, pp. 620-626, with maps, April 30, 1894. Mention should have been made in this paper of the fact that Prof. G. Frederick Wright and party, including Prof. A. A. Wright, visited some of the gravel pits east of Cartier in the autumn of 1892. See Prof. G. F. Wright's paper, "The Supposed Postglacial Outlet of the Great Lakes through Lake Nipissing and the Mattawa River," Bulletin, Geol. Soc. Amer., vol. IV, pp. 423-5, with Dr. Robert Bell's remarks in discussion, pp. 425-7.

The highest shore line was found on the hills north of North Bay at an altitude of about 1,140 feet above the sea level, and again eight miles east of Cartier on the Canadian Pacific railway at about 1,200 feet.

SUMMARY AND CONCLUSIONS.

The altitudes of the beaches observed are summarized in the following table. The measurements were all made by aneroid from points of known altitude near by. The letter *r* stands for *beach ridge* and the letter *t* for *terrace*.

Barrie	*r*	780
Lorneville	*r*	815
Orillia	*t*	830
Midland	*t*	820
Gravenhurst	*r*	825+ ?
Bracebridge	*r*	975
Huntsville	*t*	1,000
Burk's Falls	(Spencer)	1,171 ?
Sundridge	*r*	1,205
South River	*t*	1,220
Trout Creek	*t*	1,145+ ?
North Bay (at Nelson's)	*r*	1,140
Cartier	*t*	1,200

The facts show clearly that the same water that filled the ancient channels in the southern highlands extended far to the north and west. It evidently covered all the lowlands of this region and, as indicated by the altitude of the shore line, made a strait over lake Nipissing at least 25 miles wide and 500 feet deep, and probably another farther north over the hight of land to Hudson bay. There is also much reason for supposing its extension down the Ottawa valley to the lower plains of Ontario and the area of well established marine submergence. But it seems probable that the highest shore line has not yet been recognized in those parts. I am, therefore, much more confident of the truth of a statement made in a previous paper,* that the upper beach of the Nipissing region is one with the Iroquois beach of the Ontario basin. The country through which the connecting link probably passes is extremely rough and the difficulties of exploration will be great, but probably not greater than those of some other regions where good results have rewarded persevering explorers.

*"The Highest Old Shore Line on Mackinac Island," Am. Jour. Sci., III, vol. XLIII, pp. 210-218, March, 1892.

At several of the places mentioned the shore lines are in long valleys between the hills, and must have been many miles from any large open water. This is the case especially at Huntsville, Burk's Falls, Sundridge, and South River. On this account it might be thought that these evidences of submergence were not produced by the wider waters which filled the basin of the upper lakes, but were due to lakes of the glacial recession, or to some other local cause. But I am quite certain that such is not the case. These valleys are wide and have open connection with the broader lake basin outside, and the plane of the shore lines in them appears to be the same as that of the greater outer beaches. These valleys open to the southwest and west, away from the probable direction of ice retreat. The one which passes Sundridge and South River opens both to the southwest and north. The magnitude of the phenomena also comports well with the strength and character of the outer lines. At the time of the great submergence this coast was somewhat like the present coast of Georgian bay, except that both channels and islands were on a much larger scale. The highest part of the highlands lies 30 or 40 miles to the east of Burk's Falls, and is comprised in the Algonquin Park lately projected by the Canadian government.* From all that I have been able to gather concerning the character of that region it seems probable that nearly the whole tract was intersected by channels which cut it up into islands. The highest lakes reported in that region have an altitude of about 1,405 feet above the sea.

In the Simcoe region and to the west Dr. Spencer found a marked rise of the Algonquin beach toward the east. Our observations in the same region were less extended and less precise than his, but so far as they go they show the same result. For instance, the locality near Lorneville is about 30 miles east from Barrie and only two or three miles north. But the beach at the former place is about 35 feet higher than at the latter, showing an eastward rise of nearly one foot per mile. Orillia is about 13 miles east and the same distance north from Barrie and the beach is about 50 feet higher, showing a rise of more than three and a half feet per mile to the

*Report of the Commission on Forest Preservation and National Parks, etc., 1893.

northeast. The beach near Midland is about 22 miles west and ten north from Orillia. But its level is ten feet lower. This probably does not mean a northward descent from Orillia, but rather a strong eastward rise from Midland. From the locality near Lorneville to that near Midland is about 40 miles west and 20 miles north; but the beach at Lorneville is five feet the higher. The beach at Barrie, however, is 40 feet below that at Midland, showing that the apparent absence of the northward rise is due to the obscuring effect of the eastward rise. The same is probably the case between Midland and Orillia. The value of a comparison where the differences are small, however, is considerably impaired if it depends on measurements made by aneroid barometer, as is the case with our work.

From Orillia to North Bay the direction is nearly due north, and the intermediate places deviate but little from that line. The measurements of altitude are probably fairly accurate at all the places except Bracebridge, where the weather conditions were not good, and the margin of error may be somewhat larger. Taking the figures as we have them, the northward rise from Orillia to Bracebridge is a trifle over 4 feet per mile; from Bracebridge to Huntsville, less than $1\frac{1}{2}$ feet; from Huntsville to Sundridge, about 6 feet and 2 inches; from Sundridge to South River, about 3 feet; and from South River to North Bay, a northward descent of about $2\frac{1}{4}$ feet per mile.

Perhaps the most interesting result of these excursions was the finding of the great silt beds. When we take into account all their relations to the adjacent glacial and postglacial deposits, the wideness of their distribution, and their remarkable uniformity of composition in all places, it seems impossible to miss their meaning. These deposits were found not only in the highlands east of Georgian bay as here described, but also at several other distant places. They were found at Superior opposite Duluth, and at Sault Ste. Marie; at many points along the Spanish and White Fish rivers north of lake Huron; all along the north side of lake Nipissing, and up the valley of the Veuve; at Pawassan, Trout Creek, South River, Burk's Falls, Huntsville and Bracebridge, on the line of the Northern and Pacific Junction railway; in the valley of the Oswegatchie river near Edwards and South Ed-

wards, N. Y.; and again in the valley of the Missisquoi river in northern Vermont. In all these places this deposit presents not only the same general appearance and relation to other contiguous deposits, but also a remarkable uniformity of finer details. Take, for example, the silt beds at Bracebridge. The whole set of phenomena at this place is extremely instructive. The laminations of clay and silt are associated in pairs which are almost without exception about half an inch in thickness. On weathered surfaces the principal part of each layer is a greenish gray clay, and this is separated from the next layer of clay in each case by a layer of white silt, an eighth to a sixteenth of an inch in thickness. There are some variations in the composition of the deposit at each locality, but they are confined chiefly to varying proportions of the two materials. In a few places I found the clay almost absent and the silt layer thicker than usual. In other places the variation was reverse of this. It seems plain enough that the silt and the clay must represent two slightly different conditions of sedimentation; and the orderly way in which the layers alternate shows that a layer of silt and a layer of clay taken together constitute one complete round of change. This points to recurrence and almost certainly to periodicity. Tides, storms, and the annual round of the seasons, are the only recurrent variations liable to affect sedimentation. Of these the tides and the seasons are periodic, but storms are irregular. Neither tides nor storms afford a satisfactory explanation. For the one is much too short in its period, and the other too irregular. It seems impossible that the pairs of layers can represent anything but annual periods of deposition, and if this be the case several important conclusions follow. Considering the great thickness of the whole deposit, the length of time which must be allowed for its formation can hardly be less than several thousand years. Indeed, if we suppose the laminations to be uniform, and the maximum depth of the whole original deposit to have been 100 feet, the time of deposition would be about 2,500 years. And this, it should be noted, would be not the whole time of the submergence, but only the time during which the conditions of still-water sedimentation existed at that level, not counting the two periods unfavorable to this kind of sedimentation, one as

the water was rising and the other as it was receding, during both of which shallow water conditions prevailed. The gravel beaches and silt beds, with the intervening zone of dunes and sand ridges, complete the testimony that the submergence was not only of long duration, but that it was an invasion of waters of great extent. Taken alone the silts prove only a long duration of time, such as might characterize the deposits of a small lake. But the gravel spits and beaches were made by waves, which came in from Georgian bay over the basin of Muskoka lake, and these forms prove the wide extent of the water.

It has been held by many that all the abandoned relics of submergence found within the St. Lawrence basin are due to ice-dammed lakes formed during the glacial recession. But the shore lines have now been traced so far northward toward the center of the glacial radiant of the Laurentide plateau that this view seems no longer plausible. The inference nearest at hand is that the submergence was an invasion of the sea and that the Great Lakes were connected with it through a strait over lake Nipissing. It is not more than 25 miles from the Nelson beach northeast of North Bay to the nearest point on the Ottawa river above Mattawa. There is much reason to expect that exploration will ultimately prove that the upper silts and gravel beaches of the highlands of all the upper Great Lakes are of the same age as the higher postglacial marine deposits of the lower Ottawa and St. Lawrence valleys.

A REVIEW OF THE HISTORY OF THE GREAT LAKES.*

By J. W. SPENCER, Ph. D., F. G. SS. (L. and A.).

(Plate VIII.)

CONTENTS.

*Read before Section E of the American Association for the Advancement of Science, at the Brooklyn meeting, August 20, 1894.

1. Problems and Progress. "Problems settled in the rough and ready way by rude men, absorbed in action, demand renewed attention and show themselves to be still unread riddles; when men have time to think . . . . doubt . . . refuses to be cast out." In such a condition was our knowledge of the history of the Great Lakes, tributary to the St. Lawrence, when the writer commenced his fragmentary studies fifteen years ago. In these studies of the lakes some of the most interesting and important questions in dynamical, agricultural, and artistic geology are involved. Even if the Great Lakes had attracted the attention due them, their study would have been impracticable at an early date, at least until after numerous soundings had revealed their character; and until the railway surveys were made, for these furnish data for quantitative measurements. Many deep well-borings were needed to discover the buried valleys; and the surveys of the deserted shores have delimited the boundaries of the shrinking lakes, and made known the deformation of the earth's crust.

From intimate familiarity with the topographic features of the southern states, and by comparing them with those of the lake region, one can easily see that there would be very little difference between the features of the two areas, if the superficial drift at the north were removed and the country were then compared with that at the south where there is no such mantle. Accordingly the meteoric origin of the great St. Lawrence basin suggests itself; but the basin has been obstructed and several great lakes now occupy what were once broad rolling plains. Before men had time to study the lake history we were told that the lakes were valleys of erosion, but how they were made was hardly a question worthy of consideration. Later, it was an equally rough and ready method to tell us that the basins were excavated by glaciers. Their whole history is not yet written, but many chapters are now before us. Extracts of these will be given in their natural order (not in that of the discoveries), so that a short story of the lakes can be told.

2. Former High Continental Elevation. As will be shown in the next paragraph, the basins of the lakes are more or less like erosion valleys. The deepest sounding of lake Ontario is

491 feet below sea level; of lake Michigan, 262 feet; of lake Huron, 168 feet; and of lake Superior, more than 400 feet. Consequently, if these were erosion valleys, they must have been formed at such an altitude that the drainage of the region could have descended to the sea. As collateral evidence of the high elevation, we find that the lower St. Lawrence river and the Gulf are only a deeply submerged river valley, with tributary canyons, having a general depth increasing from 1,200 feet to 1,800 feet, but much deeper at the edge of the continental plateau. Hudson strait, the Gulf of Maine, New York harbor, and other points along the continental margin, reveal great submerged canyons that were once river valleys. Indeed, portions of the continent were once very much higher than now, especially in the south. where the coast and the Antillean region appear to have sunk from one and a half miles to two and a half miles during the Pleistocene period. These changes of level have been in undulations, with the greatest subsidence along the coastal regions, and more particularly in the south than in the north. But this forms a separate and partly written chapter, in which much progress has recently been made. It is sufficient to know that the lake region has stood at a high elevation during most of the time from the Carboniferous to the Pleistocene days, which were followed by changes of level resulting in the present altitude of the land.*

3. Character of the Lake Basins. The valley-like character of the lake basins appears to be challenged when the casual observer finds that some of the outlets are mostly obstructed by rocky barriers. This condition gives rise to the hypothesis of the glacial origin of the basins, for the theorist did not stop to compare the course of the basins and the escarpments with the direction of the glacial striæ. However one might doubt the correctness of the fluviatile hypothesis, the futility of the glacial origin could only be confirmed when the causes of the barriers closing the lakes were discovered, which will

---

*Previous papers on this subject by the present writer are: "High Continental Elevation preceding the Pleistocene period," Bulletin Geol. Soc. Am., vol. I, 1889, pp. 65-70; "Post-Pleistocene Subsidence versus Glacial Dams," Id., vol. II, 1890, pp. 465-476; "Terrestrial Subsidence southeast of the American Continent," Id., vol. V, 1893, pp. 19-22. Each of these papers is accompanied with a map.

be shown to have been the drift filling the old valleys and the warping of the earth's crust. But the basins are river-like and broad submerged valleys. Lake Ontario is 247 feet above the sea, but its greatest depth is 738 feet; and throughout a considerable portion of it, the southern side is bounded by high vertical but submerged walls, which for long ages formed bluffs along the ancient river.* Besides the longitudinal trough, another deep channel crosses the basin east of Toronto. Lake Erie is 573 feet above tide, but it is generally less than 100 feet deep, except over a small area where it is 210 feet; but beneath the waters of the shallow basin there are many buried channels, the deepest of which, at Cleveland, is 228 feet (Newberry). Lakes Michigan and Huron and Georgian bay, are at one altitude, 582 feet above the sea. Georgian bay is generally less than 200 feet deep, but at its southwestern side a channel reaches to a depth of 510 feet, in front of the foot of a very high escarpment, part of which is submerged. Another submerged escarpment crosses lake Huron. This has a descent of more than 400 feet. The deepest sounding is 750 feet. The two basins of lake Michigan (respectively 864 and 576 feet deep) have vertical submerged escarpments adjacent to them. Also there are some deep channels and fjords, one of which is 612 feet deep. Lake Superior has been studied less. More or less drift is known to occur between the lake basins, like that filling the submerged channels under lake Erie. The buried valleys will explain the connection between the lakes.

4. Glaciation of the Region. The striæ are nowhere parallel to the direction of the escarpments, whether these be submerged or above the level of the lakes, where they form bold topographic features. Nor are the vertical walls of the limestone escarpments polished by lateral glaciation. In short, the striæ are at considerable angles, even at right angles, to the rocky escarpments. Thus it appears that the valleys were not shaped by glacial action.

---

*"Notes on the Origin and History of the Great Lakes," by the writer, Proc. Am. Assoc. Adv. Sci., vol. XXXVII, 1888, p. 197; "Origin of the Basins of the Great Lakes of America," by the writer, Quart. Jour. Geol. Soc., London, vol XLVI, p. 523 (also in AMERICAN GEOLOGIST, vol. VII, pp. 86-97, with map of the ancient Laurentian river system, Feb., 1891); and earlier papers.

5. *Buried Laurentian Valley.* Below the outlet of lake Ontario, the valley is covered to some extent with drift, but the greater part of the barrier closing the lake is rocky. Between Georgian bay and lake Ontario, the writer discovered a deep buried valley (by a series of borings, for there was no superficial evidence of it, although parallel to the Niagara escarpment), beneath the great drift ridges intervening between the two waters. The full depth has not been reached, although not less than 750 feet beneath the higher ridges, and it is probably very much deeper, as indicated by the fjords at both ends (in lake Ontario and in Georgian bay); so that here is the connecting valley between the submerged channels of the upper lakes and lake Ontario. The fjords of northern Michigan and the buried channels continue the evidence that from lake Michigan to the outlet of lake Ontario, the ancient Laurentian river flowed partly through the basins and partly across the country north of Toronto. The ancient river is thus named to distinguish it from the modern St. Lawrence river. The connection of the valley of Superior with the Laurentian river has not been determined; but judging from soundings in lake Michigan, we may suppose it to have been by way of the northern end of that valley.*

6. *Buried Tributaries.* A branch of the Laurentian river, now buried beneath 500 feet of drift, extended from the southern basin of lake Michigan across the Michigan peninsula and the southern end of the Huron basin. This large tributary, which has been named the Huronian river, is of the same age as the Laurentian river.

Through the Erie basin flowed the now buried and submerged Erigan river. Niagara river was not then in existence. But the Erigan passed from the Erie basin across the province of Ontario to the great canyon at the head of lake Ontario, thus descending to the lower basin.

Many branches and smaller tributaries are known to have joined these greater rivers, as revealed by the borings. In some cases there were no changes in the direction of the ancient and modern drainage. In other cases the streams have locally left the original waterways and again returned to the

*"Origin of the Basins of the Great Lakes," cited before; also "Discovery of the Preglacial Outlet of the Basin of Lake Erie into Lake Ontario," by the writer, Proc Am. Phil. Soc., Philadelphia, 1881.

old valleys. A characteristic of the former drainage is the filling of the ancient channels, above which the modern streams flow upon the accumulation of drift. The ancient valleys are relatively much shallower but broader than the modern, with sides more sloping and other marks of greater antiquity than the modern streams, where they have cut new channels in place of reopening the buried valleys.

7. *Reversal of the Drainage of the Upper Ohio and other rivers.* Among the earlier studies on buried valleys were those of Dr. J. S. Newberry, Dr. T. Sterry Hunt, and Mr. J. F. Carll. To Mr. Carll belongs the credit of first working out the reversal of the drainage of western Pennsylvania, where he discovered that the upper Allegheny and some other streams flowed into the Erie basin before the Pleistocene period. In 1881 the writer, following Carll, pointed out that there is evidence that the whole upper Ohio river, above the Beaver tributary, flowed to the Erie basin. This hypothesis was amplified by Dr. P. Max Foshay, and later the observations have been extended by Prof. T. C. Chamberlin and Mr. Frank Leverett, confirming the change in the direction of the drainage. The streams south of lake Erie generally drain a much smaller basin than formerly. So in New York, the upper waters of the Susquehanna, and of its tributaries, drained to the north into the Ontario basin, by way of the Finger lakes, which now occupy the old river courses, partially closed up by drift deposits and by terrestrial warping or deformation towards the north.

8. *Closing of the Valleys into Lake Basins.* The old Laurentian valley was more than a hundred miles wide, but it was interrupted by the deposition of drift in many places, most notably between Georgian bay and lake Ontario. To some extent the modern St. Lawrence river is flowing over a drift-filled valley. This obstruction has caused the modern drainage to be changed from the old directions and often to pass over rocky barriers. But in addition to the drift obstruction, we find that the recent terrestrial uplift has been greatest toward the northeast, producing barriers and forming basins. The warping has been measured and is found sufficient to account for all the rocky barrier below the outlet of lake Ontario. Moreover this northeastern elevation has caused all the

lakes to rise and flood their southern and western ends, since the modern lakes were established. The quantitative character of this change will be explained in the next paragraph, and the effects upon the modern drainage beyond.

9. *Deserted Beaches in the Lake Region and their Deformation.* The Laurentian lake region abounds with the remains of deserted beaches, terraces, sea-cliffs, and other evidences of former shore lines. The writer has made an extensive survey of these phenomena in Canada, across Michigan, in the Adirondacks, and in the Green and White mountains.* Mr. G. K. Gilbert did the first systematic work south of lakes Ontario and Erie.† Mr. F. B. Taylor has more recently extended the surveys north of lake Michigan and northeast of lake Huron;‡ and Dr. A. C. Lawson, north of lake Superior.§ There has been very little systematic work in the lake region upon these problems except by the named observers. Some of these old shore lines, after forming highways known as ridge roads, have been surveyed for hundreds of miles; others are broken or interrupted. Generally speaking, the northeastern extensions are unknown, owing to the want of surveys; to the changes in the topography, rendering their surveys difficult; to our ignorance of the phenomena; to our ignorance of suspected modern faults; and to our further ignorance as to how much the phenomena are ob-

*"Notes upon the Origin and History of the Great Lakes," cited before; "Deformation of the Iroquois Beach and Birth of Lake Ontario." Am. Jour. Sci., III, vol. XL, 1890, pp. 443-451; "Deformation of the Algonquin Beach and Birth of Lake Huron," id., vol. XLI, 1891, pp. 12-21; "High Level Shores in the Region of the Great Lakes and their Deformation," id., pp. 201-211; "Deformation of the Lundy Beach and Birth of Lake Erie," id., vol. XLVII, 1894, pp. 207-212; "The Iroquois Shore north of the Adirondacks," Bulletin, Geol. Soc. Am., vol. III, 1891, pp. 488-491. Each of these papers, excepting the one last cited, is accompanied with a map.

†"The History of Niagara River," Sixth Annual Report of the Commissioners of the State Reservation at Niagara, for the year 1889, pp. 61-84, with eight plates (also in the Smithsonian Annual Report for 1890); Proc. A. A. A. S., vol. XXXV, for 1886, pp. 222, 223.

‡"Reconnaissances of the Abandoned Shore Lines of Green Bay and of the South Coast of Lake Superior," AMERICAN GEOLOGIST, vol. XIII, pp. 316-327, and 365-383, May and June, 1894; "The Ancient Strait at Nipissing," Bulletin, Geol. Soc. Am., vol. V, pp. 620-626. Each of these papers has a map.

§"Sketch of the Coastal Topography of the North Side of Lake Superior, with special reference to the Abandoned Strands of Lake Warren," Twentieth Annual Report, Geol. Surv. Minnesota, for 1891, pp. 181-289, with map and profiles.

literated by ice action. This last question involves the problems of subsidence of the region and of the character of ice dams. The writer regards the beaches as substantially formed at sea-level (as some of the beaches unquestionably were), although the outlines may have been obstructed by glaciers, floe-bergs, or local ice accumulations, or perhaps the northeastern continuity of the beaches is obliterated by recent faults. These are unsettled questions. Much is still to be done in the survey of the ancient lakes, yet we have some interesting contributions to record concerning them, even without inquiry here as to the still unread history.

Fragments of beaches occur in the peninsula between lakes Ontario, Erie and Huron, up to altitudes of about 1,700 feet; and terraces are found in the Genesee valley at a much greater hight, besides others at high levels elsewhere in the lake region. But when we descend to an altitude of 778 feet, at the head of lake Erie, we are at a beach of great extent (to the northeast this rises several hundred feet); and one still more extensive is reached by descending to 653 feet. All the higher shore developments are the remains of the first waters that covered the drift at the close of the Pleistocene period, whether they were ice-bound arms of the sea, or held by glacial dams, or by undiscovered land barriers since deformed by terrestrial movements. The beaches were water-levels, but now they rise toward the north and east in increasing ratio. At the head of lake Erie they are nearly level; at the eastern end of this lake the northeastern rise is between three and two feet per mile, according as we take the uplift on the higher or lower beaches. East of Georgian bay the deformation is four feet; and near the outlet of lake Ontario it is from five to six feet per mile towards the northeast, but increases onward to seven and a half feet per mile. These rates of ascent are recorded in shores not the highest; and there were many lower stages of the lakes.

10. Warren Water. The contracting waters of the Great Lakes region, represented by the succession of beaches, the writer named the Warren water,—the ancestor of all these lakes; and its lowest strand is the Forest beach, which at the head of the Erie basin has an elevation of 653 feet above the sea. This lake, during part of its history, covered 200,000

square miles. But to the east it has not been defined, and its old margins have been very considerably tilted. With the continued rise of the land, the waters sunk to a lower level, dismembering Warren water and producing:—

11. Algonquin and Lundy Waters. When the level of the water fell about 150 feet below the level of the Forest beach, the upper three lakes were enclosed within the Algonquin beach, and Erie within the Lundy beach, which latter extended to the Ontario basin. At that time the waters of the lakes did not reach to their western and southern boundaries of to-day. Toward the northeast they connected by straits with the waters in the Ontario basin, but their eastern limit has not been surveyed.

12. Iroquois Water and Birth of the Modern Lakes. The waters gradually subsided to 300 feet below the planes of the Algonquin and Lundy beaches when the Iroquois shore commenced to be formed. This level has been proved to have been that of the sea, although it is now 363 feet above tide at the head of lake Ontario, 750 feet near the outlet of the lake, and nearly 1,500 feet at the northeastern extension of the Adirondacks. The old water plane is recognizable, by either continuous or interrupted portions of its shore line, all the way to the depression of lake Champlain, but it is not yet fully known, especially as to its location north of the Ottawa river. Lower beaches are also known in the Ontario basin.

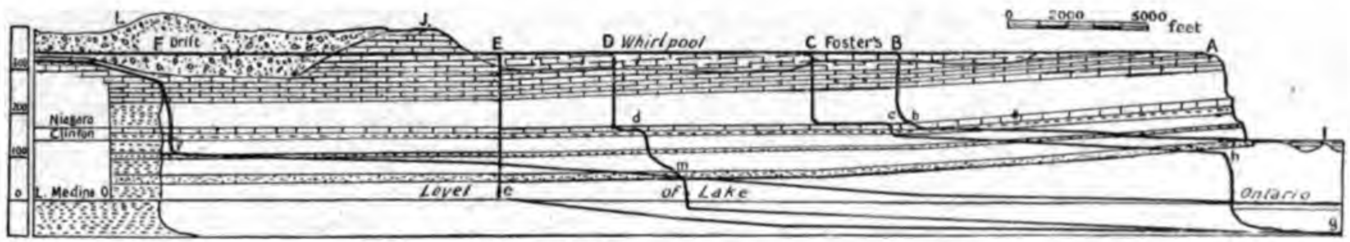
With the subsidence of the waters to the Iroquois level, the upper lakes shrunk within their narrow limits, and the Niagara river had its birth, at first draining only the Erie basin, whilst the three upper lakes outflowed by way of the Ottawa valley. Indeed, the Iroquois waters sunk more than 220 feet below the Iroquois beach, thus greatly reducing the area of that lake. The waters of the upper lakes also sunk so as to form sheets of very contracted proportions. By the continued rise of the land towards the northeast, the rims of the lakes were raised, backing the waters in the basins and extending the modern lakes as we see them. This rise was intermittent, but, for the average of the secular episodes of movement and repose, the warping in the Niagara district appears to have been a foot and a quarter in a century, and it was double that

amount at the outlet of lake Ontario, but almost zero at the head of lake Erie.

13. History of the Niagara River and Changes of the Outlets of the Lakes. From a recently written paper I make the following extracts, concerning the changes and recession of Niagara falls (Plate VIII). Upon the dismemberment of Lundy water, the Niagara river came into existence, and for a time (taken as 1,000 years) drained the infant lake Erie without cascading over a fall. The waters of the lower lake slowly sunk so that the total hight of the fall was 200 feet, with only the drainage of the Erie basin, or about $\frac{8}{11}$ of the modern volume of the water. The early falls are almost exactly reproduced in the magnitude of the American falls. The duration of the first episode is computed at about 17,200 years. Again the waters subsided in the Ontario basin (80 feet lower than now) so that the total descent was 420 feet. At that time the falls receded by three cascades (like the Genesee of to-day), at first with only the discharge of the Erie basin and afterwards with the drainage of all the upper lakes. This condition is computed to have lasted 10,000 years. Then succeeded one united fall of 420 feet, which lasted 800 years. Finally the northeastern part of the Ontario basin rose so that the descent of the river waters was reduced to 365 feet and afterwards to about 320 feet (the downfall from the head of the rapids above the falls to the lake below). This adds 3,000 years to the age of the falls. Thus, it can be seen that the age of the Niagara river is computed to be 32,000 years. It is now well established that the three upper lakes have discharged only a comparatively short time into the Erie basin, having formerly sent their waters to the Ottawa river. This change in the direction of the outlet is calculated at 8,000 years ago, when the northeastern terrestrial tilting turned the drainage into the Erie basin.

About fifteen hundred years ago, the differential uplift in the Niagara district and the recession of the falls through the Johnson ridge, a short distance below the present site of the falls, were competing for the mastery, and in the meanwhile the four upper lakes rose so high as to commence to send their waters to the Mississippi river. But the ridge was cut through and the waters were lowered to the exclusive Niagara drain-

LONGITUDINAL SECTION OF THE NIAGARA GORGE, SHOWING THE RETREAT OF THE FALLS AND THE GEOLOGICAL STRUCTURE.



EXPLANATION.

A. Brow of escarpment and original site of the fall.
I. Iroquois beach and level of that water.
B, b, I. Gorge or chasm at the end of the first episode.
C, c, h, g. Falls retreating in three cascades; but from *h* to *g* the slope was extended over a distance of twelve miles beyond the escarpment.
D, d, m, g. Cataract and gorge at the end of the second episode.
E, e, g. Development of the gorge at the end of the third episode.
F. Present site of the falls.
F, f, m, g. The present gorge from the falls to lake Ontario, by which its lower portion is partially submerged.
g. Level of the lowest lake stage during the Niagara river history (80 feet below the present lake level).
L. Lundy beach, capping the drift.
J. Johnson ridge.

Broken shading about the whirlpool shows the occurrence of drift on the west bank only, with the rock on the eastern; block shading represents limestone; dotted, sandstone; broken lines and unshaded portions, shales. The bottom of the river is about 80 feet below the present surface of lake Ontario, as shown in the figure.

age. If the terrestrial elevation of the land shall continue as for the last 1,500 years, the barrier across the outlet of lake Erie must rise so high as to turn the drainage of the lakes into the Mississippi, by way of Chicago; and it is computed that the end of the Niagara river and falls, under such conditions, will be about 5,000 years hence.

All these estimates are based upon the rate of recession of the falls and the amount of work done in each episode, as discovered in working out the history of the lakes. In 1842, Prof. James Hall made the first instrumental survey of the falls. The next was made in 1875 by the Coast Survey. In 1886, Prof. R. S. Woodward made the third; and in 1890 Mr. Aug. S. Kibbe made the last. From these four surveys, the mean rate of recession of the falls (that is, the mean elongation of the gorge) was found to be 4.17 feet a year. But the river in the region of the falls is now crossing a pre-Pleistocene valley, where the hard surface rocks have been removed for 80 or 90 feet in depth beneath the rocky ridge crossing the course of the canyon a short distance below the present site of the falls. Thus the amount of work now being done by the river is much less than the average demand upon the stream during the greater part of the life of the river. Before 1875 all statements as to the age of the river were pure conjectures, but that of Lyell was nearly correct. The estimates made upon the retreat of the falls alone have proved to be not even so accurate, although the method was better as far as it went; but it stopped short of the history of the falls. Again, speculations as to the ancient Niagara flowing down by the Whirlpool-St. David's valley have been disproved by the rock which crosses that course hundreds of feet above the lake level; instead, the Niagara here touches a little buried tributary of an ancient stream to the west.

In conclusion, the Niagara falls serve as a chronometer of geological time, as they give some idea of the epoch of the lakes. If the Ice age ended with the birth of Warren water, then we can roughly estimate it to date back some 50,000 or 60,000 years. At the birth of the Niagara river and falls, and long before, there was no ice barrier in the Niagara district. Lastly, if we regard the Iroquois water as at any time obstructed by ice, such conditions have not existed since the

close of the episode which ended 14,000 years ago. Whilst, however, the date of the decadence of the Ice age in this region is told, the falls do not necessarily record its termination in other and distant regions.

14. Recurrent Drainage of the Great Lakes into the Mississippi River by way of Chicago. Long ago, Dr. E. Andrews described the deserted beaches south of Chicago, and found that the highest reaches an elevation of 45 feet above the lake. For many miles around the head of the lake, the deserted shores are found far inland. There are other raised beaches near the lake. The different sets form an apparent succession, but in reality there is confusion between the old water-margins and the very recent beaches. The low plain at the head of the lake rises so gradually that at the divide between it and the Mississippi drainage southwest of Chicago it is only eight feet above the lake, with a rocky floor a foot or two lower (canal survey). In proceeding northward along the margin of the Michigan basin, beaches are found emerging from beneath the waters. From the measured deformation of the various sets of deserted shores, the depth to which the tilted beaches are depressed beneath the lake can be calculated.* These record the shrinking of the lake from the highest level south of Chicago to others even hundreds of feet beneath.

The Ridgeway beach extends from the Erie basin across southern Michigan, by way of Saginaw bay and the Grand river valley, and southeast of lake Michigan it descends and is lost in the sand dunes of that region; but, with the measured rate of deformation, it is computed to pass about 40 feet beneath the surface of the water. The Forest beach, the last strand of Warren water, is about 100 feet lower. The still lower Algonquin beach (the great shore line of the dismembered upper lakes) occurs well defined about the northern half of the lake (Andrews and Taylor); but if produced to the southern end of the basin, it would be submerged between 250 and 300 feet. There are other lower and less important deserted shores; but all these represent the subsiding of the lakes during the time of discharge of the waters of lake Huron

*"High Level Shores in the region of the Great Lakes and their Deformation," before cited.

by way of the Ottawa river, which is found to have drained the Huron, Michigan and Superior basins for about 24,000 years.

The highest of the beaches about the head of lake Michigan (at 45 feet) has been regarded as the equivalent of the Maumee beach, or not a lower strand, and therefore the oldest well defined beach of the region, although it is only a few feet above the present and recently deserted shores.

Owing to the terrestrial deformation, the Ottawa outlet of the Huron basin was closed by the rim being raised so high as to turn the overflow into the Erie basin. This northeastward uplift also affected the outlet of the Erie basin, and on account of the presence of the Johnson ridge, about a mile north of the present site of the falls of Niagara, caused an actual overflow of the drainage of all the upper lakes into the tributaries of the Mississippi. At that time the lacustrine silts upon the prairies at the head of lake Michigan were laid down. But the Niagara falls were receding at the rate of about four feet a year and completed the incision through the Johnson ridge about 1,500 years ago,* thus overcoming the terrestrial uplift of the Niagara district (which is about a foot and a quarter a century), and then the level of lake Erie was lowered to about 17 feet below the Chicago divide. The slightly raised beaches about the head of lake Michigan mark this late subsiding of the waters. The lowering of the waters by the recession of the falls has preserved the present outlet of the lakes for a further period, but if the late rate of terrestrial deformation shall continue in the future, the drainage of the upper lakes will be diverted from the Niagara into the Mississippi in perhaps 5,000 or 6,000 years, so that this result will be reached before the falls shall have receded to Buffalo.

DRAINAGE SYSTEMS OF THE CARBONIFEROUS AREA OF MICHIGAN.

By E. H. Mudge, Belding, Mich.

The rock formations of Michigan commonly referred to the Carboniferous period, include the Subcarboniferous limestone

*"Deformation of the Lundy Beach and Birth of Lake Erie," before cited.

and the Coal Measures proper. The former is of limited development and often entirely wanting. The area occupied by these formations is roughly circular in form and is located in the central part of the lower peninsula. It covers not far from 10,000 square miles, including fourteen entire counties and parts of as many more.

Boundary of the District.

The surface is so generally covered with drift that its exact limits cannot be readily ascertained. Much of the boundary, however, may be located with reasonable accuracy from the presence of occasional outcrops. According to Prof. Rominger (Geol. Survey of Mich., vol. III, 1876), the boundary is about as follows: Commencing at a point on Saginaw bay, in the northern part of Huron county; thence southwesterly in a gentle curve to the southern part of Jackson county, within about 30 miles of the southern state line; thence northwest to the vicinity of Grand Rapids, about 25 miles from lake Michigan; thence north, northeast and east with a sweeping curve, to the north shore of Saginaw bay, opposite the place of beginning. From Grand Rapids to the vicinity of Saginaw bay the location of the boundary is largely guesswork, owing to the heavy drift with which the region is covered.

Topography.

A marked depression crosses the peninsula from Saginaw bay to the mouth of Grand river, dividing the Carboniferous area into two nearly equal parts. Its direction is southwest from Saginaw bay to the mouth of the Maple river, in Ionia county, thence west to lake Michigan. According to the late Prof. A. Winchell, one may cross the state along this line without reaching an altitude greater than 72 feet above the lakes. The highest point is in Gratiot county, probably in North Star township (T. 10 N., R. 2 W.), where the waters flowing into the Bad and Maple rivers separate. The northern and southern portions of the district incline gently to the central depression. The point where this depression crosses the western margin of the Carboniferous area is but a few feet above lake Michigan, the site of the union depot in Grand Rapids, having an altitude of only 20 feet. The eastern end of the depression merges into Saginaw bay. From these two

low-lying points the boundary rises in each direction. The northern rim attains an altitude of about 500 feet, reaching well up toward the high northern plateau. The elevation of the southern margin is perhaps a little greater.

The Drainage Systems.

An inspection of a geological map reveals at once an intimate coincidence between the drainage areas of the district and the limits of the district itself. The boundary as above described, except where it crosses the central depression, marks, approximately, the watershed between the streams draining the district and those flowing in various outward directions. This peculiarity is more particularly noticeable along the southern margin of the territory. From the vicinity of Grand river on the west, to Howell on the east, a distance of about 150 miles, the coincidence is nearly continuous, the only notable exception being in Calhoun county, where the northern branches of the Kalamazoo, rising some distance within the district, flow outwardly across the border. From Howell northeast to Saginaw bay, the boundary is some distance west of the watershed, the eastern members of the Saginaw river system rising outside the district and flowing inwardly. On the northwestern border for a distance of seventy-five miles, the Muskegon river is within the boundary and only a few miles from it, thus apparently contradicting the rule laid down above. Nevertheless the rule is in some degree applicable, as will be seen later on.

There are two principal river systems in the district, the Grand and the Saginaw, which carry off nearly all the water falling within it, and but very little from outside territory. The line of separation between them runs from the margin of the district in Livingston county in a general northwest direction to Mecosta county. The territory drained by each is broad and irregular in shape, while nearly every other stream of importance within the state occupies a more or less elongated valley. The only remaining river worthy of mention within the district is the Muskegon, which drains a narrow strip on the northwestern margin.

Genesis of the River Systems.

That the history of all the streams in this region dates from the close of the Glacial period is quite apparent. For

the most part there is no evidence to show that they occupy the sites of preglacial river valleys. With few exceptions their courses were determined by the conditions existing during the period of the disappearance of the ice-sheet. To understand those conditions clearly, a brief glance at the preglacial aspect of the Carboniferous area will prove of value.

The close of the Devonian found this area isolated from the main ocean, having been entirely surrounded by deposits of that age. It, however, retained one or more outlets through which its surplus waters were discharged. During the numerous oscillations to which the land was subjected during Carboniferous time this area was alternately an open sea in which heavy sandstones were deposited and an extensive swamp sufficiently stable to support a luxuriant flora. In either case there was always a large amount of surplus water, and hence the existence of the outlet was probably continuous. Now, when this inland sea was finally filled by the continued formation of off shore deposits the central part was presumably the newest and hence the lowest, giving a slightly concave form to the surface; the concavity being broken through at the points occupied by outlets. It seems probable that these outlets were two, one to the east discharging its waters through the St. Lawrence valley, the other flowing to the west for some distance and then south to the ocean. Starting in this condition the area was subjected for some millions of years, during Mesozoic and Cenozoic time, to uninterrupted erosive influences. The result was a transformation of the circular concave surface to a trough-like configuration; the main drainage channels occupying the line of least elevation across it, and the northern and southern portions sloping to the center. At this stage of the erosive process the country was overwhelmed by the glacial invasion. It is already obvious to the reader that the present configuration is not particularly different from that just outlined. The central depression is still a marked feature, and the two lateral portions incline gently towards it. The glacial forces modified it, but could not obliterate it. Its origin therefore dates from the close of the Devonian age. We are now prepared to consider intelligently the origin of our river systems.

Glacialists are generally agreed that the direction of ice

movement over the lake region was from northeast to southwest, with local variations caused by river valleys or other already existing surface irregularities. Thus, it is presumed that lakes Huron and Michigan mark the sites of former important streams, in the valleys of which the erosive force exerted was necessarily much greater than on the highlands, and hence the formation of the broad lake basins. This intense erosive force was also felt in the valley of the eastern Carboniferous outlet, and Saginaw bay was the result. When the continental glacier receded and thinned out, its margin took the form of great lobes which occupied the lower portions of the land. A branch of the great lake Erie lobe occupied Saginaw bay and valley and extended far across the country to the southwest. In its retreat it gave rise to two whole families of rivers.

The origin of Grand river was fully described by the writer in the AMERICAN GEOLOGIST for November, 1893. It was briefly as follows: The Saginaw glacial lobe having retreated over the watershed near the southwestern boundary of the Carboniferous district the accumulating waters flowed to the north and west along its front before rising high enough to pass over the watershed.

Retreating to the northeast down the gentle slope of the country, the waters were again unable to rise to their recent outlet, the Grand, and a second river, the Cedar, was formed. It flowed to the west, uniting with the Grand near Lansing. Leaving the Cedar in an established channel, the glacial lobe continued its recession down the slope, and in a similar manner gave birth to the Looking-glass river. This also flows to the west, reaching the Grand at Portland. Still later that part of the Maple south of the central depression was formed, probably in the same manner. All these streams flow at an angle with the natural inclination of the surface.

Though these conclusions have not been reached through a personal visit and examination of all the streams, it is believed that they are entirely warranted. The problem in brief is this: Given a glacial lobe retreating slowly down a gentle incline, and hemmed in at one side and in front by an elevated ridge, to determine the direction of flow of the waters resulting from its waste. It is clear that they would escape in the

lateral direction remaining open to them. Now these are exactly the conditions existing here. The circular form of the watershed skirting the southwestern boundary of the district made it impossible for the waters to escape in any other direction than that taken by the rivers mentioned.

The second family of rivers originating in connection with this glacial lobe was the Saginaw system. This consists of the Cass, Flint, Shiawassee and Tittabawassee rivers, which unite into a single stream some fifteen or twenty miles above the head of Saginaw bay, and not more than six or eight feet above its level. To make out their origin in detail would require further careful investigation, but some conclusions or inferences may be safely drawn. These streams, as a system, flow in the direction of glacial retreat, that is, down the valley. It may, therefore, be inferred that they did not originate in the escape of glacial waters. The courses of the Cass and Tittabawassee are, however, a little abnormal. The former rises to the southeast of Saginaw bay, while the latter has its source far to the northwest. Instead of flowing directly down the slope to the bay, both of these streams take a course at an angle with the inclination of the surface and meet at Saginaw City, together forming a semicircle about the head of the bay. Small streams rising near them flow direct to the bay. The natural inference is that their peculiar courses are due to a line of morainal embankments formed about the circular front of the glacier.

It seems to me hardly probable that the great Erie-Huron glacial lake ever occupied this valley, or that it ever had an outlet through the pass to Grand river, as some have inferred. Such a body of water, remaining for a considerable time, would have so leveled and modified its bottom that the streams would not, after its disappearance, have taken the abnormal course above described. It is more likely that the Saginaw valley was at that time still blocked with ice. A smaller lake may have existed in front of the Saginaw lobe.

One more important stream, not related in origin to those just described, remains to be mentioned. The Muskegon rises in the north central part of the peninsula and flows directly southwest to lake Michigan, draining an area 125 miles long, with an average width of only about 25 miles. The form of

this valley is rather flat, the center being depressed about 200 feet below the marginal portions. The northwestern Carboniferous boundary is within this elongated valley for a distance of 75 miles. Our conclusions in regard to the origin of this valley and river are of a somewhat more speculative nature than the foregoing. Nevertheless, some interesting generalizations may be drawn.

It is worthy of notice, in the first place, that this valley occupies exactly the place where one would naturally expect to find the backbone of the peninsula—the line of water-parting between the streams flowing west to lake Michigan and those flowing southeast to Saginaw bay and the central depression. It is as though the original watershed had been for many miles longitudinally cleft by the river into two roughly parallel watersheds. To learn the origin of these remarkable conditions is the problem before us, to which the circumstances suggest two possible solutions.

The first is that the line of first separation between the eastern and western ice lobes was along the line of highest elevation; and upon this highest ridge, flanked by the separating lobes, the river was formed by the glacial waste and established its permanent course. This theory is, in effect, a modification of that applied by Mr. McGee to certain rivers of northeastern Iowa (Eleventh Annual Report, U. S. Geol. Survey, pp. 218, 219, 236). While this theory applies very nicely to the river, it seems quite plain that the valley did not originate in this manner. The time since the Glacial period has been too short to permit the formation of so wide a valley; and besides, its surface is now covered with drift materials and dotted with small lakes, many of them being near the stream channel, indicating that it was ice-covered after its present form was attained.

The second theory is more complex and difficult to work out in detail. It is suggested by the fact that for so long a distance the valley coincides with the Carboniferous boundary. If this valley is of preglacial origin we naturally assume that it was the result of stream erosion. The question then arises, Why should the ancient stream follow so persistently the strike of the undisturbed Carboniferous strata, rather than their natural inclination? This is a most difficult prob-

lem to shed light upon, but I would suggest that along this shore of the ancient sea a long line of sand bars may have been built up of the sediments brought in by inflowing streams. The channel between these and the mainland may have served in later time, when the swampy land had further extended itself, as a watercourse, conducting the surplus water around the margin to the western outlet. Such a stream might finally establish itself and excavate a valley. In support of this it is worthy of mention that at the present time a very slight deflection of the Muskegon river in Newaygo county, just before it leaves the Carboniferous area, would cause it to continue within the boundary until it reached Grand river and the central depression just above Grand Rapids through the valley now occupied by the Rouge river. The latter heads in Rice lake, within three miles of the Muskegon and at about the same or a slightly lower level.

In closing we wish to acknowledge our indebtedness for the elevations and general surface configuration, on which this paper is based, to a most excellent contour map of the state, prepared with much labor by the late Prof. Alexander Winchell.

THE MINERALOGICAL CHARACTERS OF CERTAIN NEW JERSEY LIMESTONES.

By Lewis G. Westgate, Evanston, Ill.

It is the aim of the present paper to describe briefly the mineralogical characters of certain of the white or crystalline limestones occurring in Warren county, New Jersey. These limestones occur along the eastern border of Jenny Jump mountain, near its northern end. They are here associated with Archæan granitoid gneisses, and are cut by dioritic eruptive rocks.

The rocks under consideration are crystalline limestones. In grain they vary between a rather fine-grained crystalline limestone, not unlike ordinary marble, and a coarse rock in which the faces of the calcite grains are relatively large. In color the rock varies from a pure white, through shades of gray, to red. Where foreign material is present in abund-

ance the rock locally takes on other colors. With regard to the chemical composition of these limestones the writer has nothing new to offer. The crystalline limestones in other parts of the state show all gradations from a pure lime-carbonate to a typical magnesian limestone, and the rocks of the area under consideration probably have much variation in the amount of magnesia present. Below is an analysis* of a sample of crystalline limestone from the east side of Jenny Jump mountain:—

Lime	42.45
Magnesia	10.23
Oxide of iron and alumina	1.00
Carbonic acid	44.67
Silicic acid and quartz	1.95

This indicates an intermediate rock between a pure limestone and a magnesian limestone.

Lithologically the rock varies greatly, but mainly in the presence and character of the accessory minerals. Crystalline calcite is usually the principal and sometimes the only mineral present. The rock is then composed of an aggregate of irregular grains of calcite. The rock is rarely, however, a pure limestone, but almost always carries a greater or less amount of accessory minerals, and it is with these that this paper is chiefly concerned. In the field the limestone is often seen to be streaked with greenish or black irregular masses or concretions. When examined under the microscope these are seen to be composed mainly of pyroxene, hornblende, magnetite and biotite. Other accessory minerals are often present in the limestone, such as quartz and, more rarely, tourmaline and apatite. Graphite and garnet were seen in the rock in certain places in the field, but were not present in any of the slides examined.

Pyroxene is perhaps the most abundant of these accessory minerals, and occurs in greenish patches in the limestone. Under the microscope it is monoclinic, has a well-developed prismatic cleavage, is colorless or very pale green, and non-pleochroic. It is probably closely related to malacolite, which agrees with it in optical properties and place of occurrence. It occurs in large, sometimes irregular, but more generally

*Geology of New Jersey, Cook, 1868, p. 402.

rounded grains, either scattered through the rock or collected into aggregates. It does not possess well-developed crystal planes. The pyroxene has very frequently altered to serpentine. Limestone is often found, hand-specimens of which are speckled with small greenish rounded masses of serpentine. Under the microscope these greenish masses are seen to be aggregates of serpentine, generally associated with granular magnetite and sometimes other decomposition products. Often, however, undecomposed fragments of pyroxene are seen embedded in the midst of the serpentine aggregate, showing that the serpentine has originated in the decomposition of the pyroxene. When serpentine occurs in the white limestone it is generally in such small masses, derived from the alteration of isolated grains of pyroxene.

Brown biotite occurs frequently in the limestone in large rounded grains, often beautifully fresh. Green monoclinic hornblende occurs, sometimes very abundantly. It is dark green in color and is present in irregular grains in the basic concretions in the limestone. Quartz is abundant. Apatite is frequently present in irregular grains. Tourmaline occurs rarely. Graphite was sometimes seen in the limestone in the field, but is not a widespread mineral. In one or two outcrops considerable quantities of red garnet weré seen in the limestone.

In some places quartz is an abundant accessory mineral in the limestone. It usually occurs in small grains or masses, and the limestone then has the appearance of holding small pebbles of quartz. Sometimes these pebble-like masses of quartz are an inch or more in diameter. Under the microscope the quartz of these masses is seen to occur in very irregular grains, with a wavy extinction, and having the appearance of vein quartz. There is nothing to suggest that they may have had a detrital origin. They are probably metamorphic.

There are two special types or varieties of rock associated with the white crystalline limestones of Jenny Jump mountain which call for special mention. These varieties are:—

(1) Pyroxene-rock.

(2) Quartz-rock.

The typical pyroxene-rock consists wholly of irregular or rounded grains of colorless monoclinic pyroxene. Very fre-

quently quartz is associated with it and in one slide considerable amounts of biotite. In the hand-specimen it is a uniform, light-green, medium-grained rock.

Quartz-rock also occurs abundantly within the limestone area. In the hand-specimen it is simply gray massive quartz. Microscopically, it consists wholly of extremely irregular and interlocking grains of quartz, usually with a wavy extinction. Pyroxene, graphite and magnetite occur in greater or less amounts associated with quartz in this rock. The term quartzite, which is applied to bedded quartz rock of detrital origin, is inapplicable here, for the rock under consideration is of an altogether different origin, as will be shown below.

In typical examples these two rocks are wholly distinct and consist of pure aggregates of pyroxene and quartz respectively. But practically the rocks grade into each other by a complete series of intermediate forms. The pyroxene-rock generally carries more or less quartz which locally increases in amount until it makes half the rock. From this intermediate quartz-pyroxene-rock there are all gradations to a pure quartz rock, owing to the gradual relative increase in the amount of the quartz over the pyroxene. In considering their origin they may be treated together, for they are the two extremes of a single continuous series.

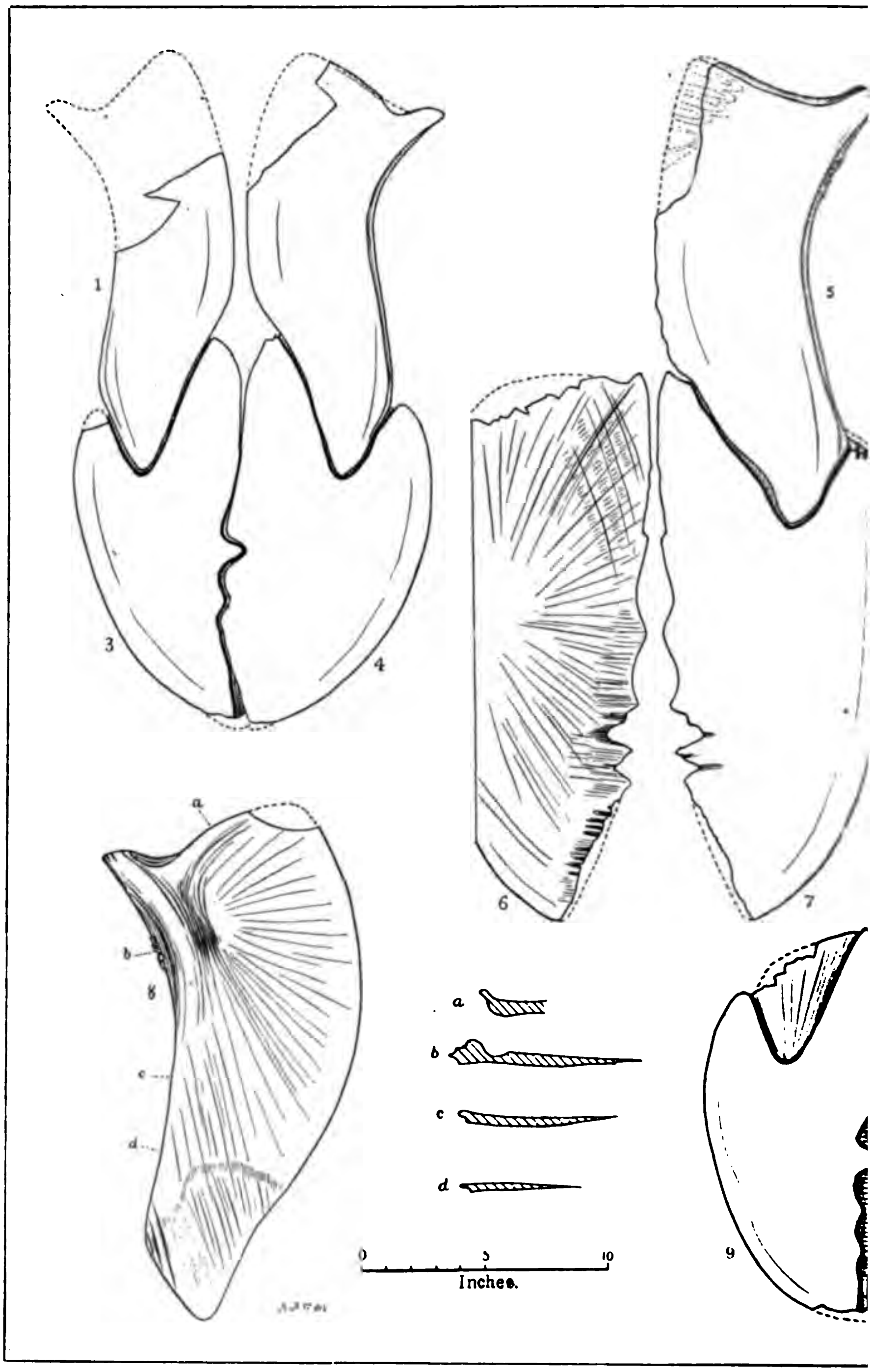
These two rocks are explained as being local phases of the limestone due to the local development, on a large scale, of the common accessory minerals, pyroxene and quartz. This is shown by the following facts:— (1) Near the north end of the mountain a dike of diabase cuts across the limestone area in an east and west direction. On the south side of the dike the rock at the contact is a quartz-rock holding patches of greenish pyroxene; further away it is a greenish pyroxene-rock without quartz; still further south it is crystalline limestone. These three varieties grade into each other. The relation of the quartz-rock to the diabase dike is accidental, for at many other points in the limestone the quartz-rock and pyroxene-rock occur at a distance from any eruptive. Other examples of the gradual passage from crystalline limestone into quartz-rock and pyroxene-rock can be given from the same region. (2) The accessory pyroxene of the normal crystalline limestone is the same in external appearance and

microscopic characters with the pyroxene of the pyroxene-rock. (3) Graphite scales are found in the quartz-rock as well as in the crystalline limestone.

The pyroxene-rock and quartz-rock appear to result from the development, on a large scale, of accessory minerals which are common everywhere in the limestone. The reason for their development is not known. It does not appear to be due to local metamorphism by eruptive rocks, but is rather a result of the general metamorphism which the limestone has undergone.

Magnetite, as has already been shown, is one of the most abundant accessory minerals of the limestone and occurs in irregular grains and aggregates. In some places this magnetite increases in proportion to the calcite until it forms the whole, or nearly the whole, of the rock, the calcite then being wholly absent or occurring in small amounts between the grains of magnetite. The rock is then frequently mined as an iron-ore. There are all gradations between a pure crystalline limestone and a typical limestone iron-ore. The origin of the limestone iron-ore is the same as the origin of the accessory magnetite which occurs in scattered, irregular grains in the white limestone. It seems most probable that both are derived from iron included in the limestone as an impurity at the time of its formation. The magnetite occurs in the limestone in scattered grains and in masses, and in beds. Where it forms beds it differs from its occurrence in isolated grains only in its relative abundance, and the beds of limestone iron-ore grade into the pure limestone beds above and below. These beds may be due to primary deposition as beds, or, as seems more probable, to a later segregation of isolated grains into planes, either bedding-planes or planes of secondary origin due to dynamic action.

It is not purposed here to enter into a discussion of the origin of these accessory minerals of the crystalline limestone. The limestones are cut by numerous eruptive rocks, mainly diorite and pegmatite, and, in a less degree, diabase. It does not seem probable that the accessory minerals are the result of local metamorphism by these eruptives, for the minerals occur widely and uniformly disseminated throughout the limestone and at a distance from the eruptives. Further, they



VENTRAL ARMOR OF DINICHTHYS.

do not occur more abundantly where the white limestone is cut by the eruptives than they do elsewhere. The more probable explanation of their presence and abundance lies in the general metamorphism which the region has suffered, resulting in the complete crystallization of the limestone and in the production of the abundant accessory minerals from the impurities which it contained.

THE VENTRAL ARMOR OF DINICHTHYS.

By Albert A. Wright, Oberlin, Ohio.

(Plate IX.)

The reconstruction of the great placoderm Dinichthys still lacks much of completion. Although many important points have been made out, through the enthusiastic labors of the collectors, Hertzer, Gould, Kepler, Terrell, and Clark, and the descriptions of Newberry and Claypole, all of which constitute one of the most interesting and important chapters in American paleontology, it is still true that much yet remains to be done, owing to the scattered and often fragmentary condition of the material upon which reconstruction depends. Every year that field work is continued brings to light some new evidence as to the relative position of the plates and skeletal elements of this fish.

It is owing to the existence, in the museum of Oberlin college, of some new and more perfect material than was in the hands of Dr. Newberry, that I am enabled to present a reconstruction of the armor that defended the ventral surface of Dinichthys. A description of this material was prepared in April, 1893, for the (now) forthcoming volume of the Ohio Geological Survey; and it is through the courtesy of the director, Dr. Edward Orton, that I am enabled to present the plate and cuts which accompanied that description here, in connection with this briefer summary of the facts.

The only accounts of the ventral armor of Dinichthys which have hitherto been published are those by Dr. Newberry in the report of the Ohio Survey* and in his monograph upon the

*Ohio Geol. Survey, Paleontology, vol. II.

Paleozoic fishes of North America.* In the first of these he gives an outline figure of Pander's restoration of the ventral armor of Coccosteus, which is here reproduced (fig. 1), ac-

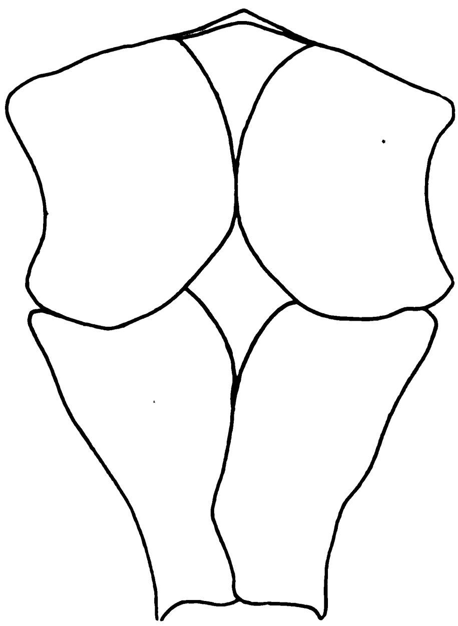


FIG. 1. Ventral armor of *Coccosteus decipiens* Ag. Natural size. (Pander's restoration.)

companied by a similar outline of the ventral armor of Dinichthys, also herewith reproduced (fig. 2). In both these figures it will be seen that there is an anterior pair and a posterior pair of ventral plates. On the median line there is, in the case of Coccosteus, a lozenge-shaped bone in the center, overlapped by both pairs of ventral plates, while anteriorly there is a triangular bone, the "antero-ventro-median." On the median line of the Dinichthys armor there is apparently only one elongated bone which corresponds in position with the two medians of Coccosteus. The ventral armor of Dinichthys was thus supposed to consist of these five bony plates:

One pair of anterior ventro-laterals,
One pair of posterior ventro-laterals,
One ventro-median.

*U. S. Geol. Survey, Monographs, vol. XVII.

At the time the monograph was written it was thought by Dr. Newberry that he had material representing two additional pairs of plates which protected the under side of the head. These were considered to be the "jugulars" and the "post-jugulars" or "hyoids," the latter pair overlapping the former pair where the extremities met. In all, therefore, nine bones have hitherto been referred to definite positions upon the

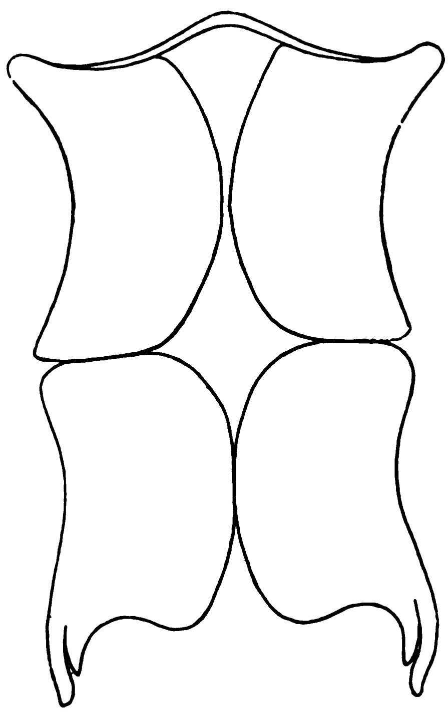


FIG. 2. Ventral armor of *Dinichthys terrelli* N., one-twelfth natural size. (Dr. Newberry's first restoration.)

under side of the fish, a jugular series of four and the above mentioned ventral series of five. This, I think, was Dr. Newberry's latest conception of the arrangement of these plates, although he himself made some alterations in his first identifications of the bones.

Prior to the publication of the monograph, specimens had been obtained which showed that the pair of supposed posterior ventral plates really belonged upon the sides of the head; and in that work they are figured in their true position and

more fully described as the suborbitals. The vacancy thus created in the ventral shield was not positively filled by anything described in the monograph. The subject is alluded to as follows: "No figure is given of the plates which are supposed to have formed the posterior half of the plastron, because no perfect ones have been found; but I have numerous fragments of relatively large plates which must have been oblong in form and had the moderate and uniform thickness and plainness of surface which characterize the plates that defended the under side of the body. As they are apparently assignable to no other place in the armor of Dinichthys, I provisionally locate them here."* Specimens of each of the other bones, except the median, are figured in the monograph, that is to say, the anterior ventro-lateral of two species, a single hyoid? and a single jugular; but these are all isolated and no diagram or figure is given which groups them in their relative positions in the armor as a whole.

A careful study of the new and well preserved material in my hands convinces me that the ventral armor of Dinichthys must be reconstructed as follows:

1st. The anterior ventro-laterals should remain in the position to which they were first assigned by Dr. Newberry.

2d. The bone figured as "hyoid" with an interrogation mark in the monograph was probably assigned to its position on insufficient evidence, and its true relations are still problematical.

3d. The arched "jugulars" must be transferred to the posterior end of the ventral shield, where they constitute the posterior ventro-laterals, the arched border being directed backwards instead of forwards. They thus fill the vacancy caused by the removal of the suborbitals to the sides of the head.

4th. The median plate or plates should doubtless retain their place as previously described by Dr. Newberry. I have seen no specimens of these, but the rearrangement proposed will scarcely affect them.

By these changes the "jugulars" and "hyoids" disappear, and the armor or other structures upon the under side of the head remain to be discovered.

---

*Op. cit., p. 138.

The facts which compel this reconstruction are as follows:

1st. The so-called "jugulars" and the anterior ventro-laterals were certainly contiguous and overlapping plates. Their natural relative position is that shown in plate IX, in figures 1 to 7, in which 1, 2 and 5 represent anterior ventrals and 3, 4 and 7 the so-called "jugulars." This relation is proved by the perfect fitting of the overlapping portions. Upon each of the "jugulars" there is a triangular, depressed area, shown in the upper portion of fig, 9, for the reception of an overlapping bone, and into this depression the thin, triangular extremity of the anterior ventral fits perfectly. The bones represented in figs. 1 to 4 are known to have belonged to a single individual, of which the cranium, mandibles and other bones to the number of eighteen were found together at one time and place. Numbers 5 and 7 of the plate were also found together at a different point. Here then are three cases in which the perfect overlapping proves that the so-called "jugulars" were the companions of the anterior ventrals. The case is so clear that I have no hesitation in saying that this relation of the plates in question is demonstrated.

2d. The "hyoid" ? bone which was figured in the monograph and believed to overlap the "jugular," is not shown to have the shape necessary for filling the depressed area in the jugular, nor is it indicated which end of the plate occupied this area. It is excluded from the association assigned to it by the facts already stated; and while it may have occupied a position in the hyoid region, the grounds for assigning it to such a position seem now to be uncertain.

3d. The size of the so-called "jugulars" is rather large, and the curvature of their outline rather strong, for the position to which they were first assigned. In the first case here figured (plate IX, figs. 3 and 4), the "jugulars" measure 16 inches in length. The curved border also measures 16 inches to the lateral angle, that is, along the margin which is supposed to have lain against the inner side of the mandible. The mandible of the same individual, however, was only 14½ inches in total length. Other specimens of the "jugulars" have been found of enormous size. For instance, one was discovered near Columbus, Ohio, to which my attention was drawn by Dr. Claypole, who kindly furnished me a tracing of it. This

plate was fully 30 inches in length, a length greater by six inches than that of any mandible known. It is, of course, possible that the jugular may have exceeded the mandible in length, but we know that the mandibles of Dinichthys were capable of the freest and most vigorous action.

In the large "jugular" just referred to, the curvature of the outer margin was strong, and similar to that of figs. 3 and 4 of the plate, where, with a length of 16 inches, we have a breadth (of the pair) of 14 inches. The curvature here is far greater than that of any mandible which I have ever seen. The curvature of the mandibles, indeed, is very slight. The single "jugular," however, of which Dr. Newberry figures the inner and outer aspects,* is of the type shown in fig. 7, where the curvature of the outer border is much reduced. It is aside from my present purpose to discuss the question whether the two types of plates here shown belong to the same species or not. I will only remark, in passing, that the plate figured by Dr. Newberry is referred by him to *D. terrelli*; while those shown in figs. 3 and 4 of the present paper are known to belong to *D. terrelli* by the structure of the dentition upon which the species was founded, and which was preserved along with the plates in question.

As we consider, therefore, the large size and the strongly curved border of the plates which have been called "jugulars," we may be the more willing to see them transferred to the posterior portion of the ventral armor, where they are freer from limitations as to size and shape.

4th. This rearrangement of the plates brings the "plastron" of Dinichthys into more striking agreement with that of Coccosteus (fig. 1 in text) than did the first reconstruction by Dr. Newberry. To the harmonies which he pointed out,† the following may be added:

(a) The overlapping of the posterior plates by the extremities of the anterior plates.

(b) The overlapping of the right posterior plate by the left posterior plate along the median line.

(c) The sinuous line of overlapping between the posterior plates in both genera.

*Monograph, Pl. VI.

†Ohio Geol. Survey. Paleontology, vol. II, p. 9.

(d) The less breadth of the posterior plates behind than in front.

The foregoing facts seem to furnish a good basis for the rearrangement of the ventral plates of Dinichthys. It is to be regretted that we are not yet able to bring the ventral armor into positive connection with the cephalic or dorsal armor, or with the position of the pectoral fins. The anterior ventro-lateral plates have their outer margins rabbeted for a certain distance, along which they were probably sutured to some other plate not yet identified. A large number of plates are in the hands of collectors and museums, for the correct location of which no sufficient clues have yet been found.

Concerning the structure of the bones represented in the plate, it may be well to explain that figures 6 and 8 represent the inner aspect of the respective bones, and the radiating lines show the direction of the grain or fibrous structure, which is more distinctly seen upon the inner than upon the outer surfaces. Fig. 8 represents a magnificent anterior lateral, the largest and most perfect, I think, which has yet been found. Several cross-sections of it are given to show the thickness and the structure of the border. In figure 3 (and 9) a remarkable device is seen by which it interlocks with figure 4 in such a manner as to prevent longitudinal displacement. A strong, transverse, tooth-like ridge stands out on number 3 which is received into a corresponding channel in the overlapping number 4. In number 7 (which corresponds to number 4) it would seem that the tooth to be received must have been much weaker. This device gives one more bit of evidence as to the turbulent life which was lived by these tyrants of the Paleozoic seas, and of the force of the attacks against which they were provided by their interlocking armor.

EXPLANATION OF PLATE IX.

Figures 1 to 4 represent the paired bones belonging to the ventral armor of a single specimen of *Dinichthys terrelli* Newb., in their natural relative positions.

FIGS. 1 and 2. Right and left anterior ventro-lateral plates.

FIGS. 3 and 4. Right and left posterior ventro-lateral plates.

FIGS. 5 and 7. The left anterior and posterior ventro-lateral plates of another and larger individual, in their natural relations. The dotted lines at the anterior end of fig. 5 denote five very shallow, transverse channels, on the inner surface of the plate, which indicate the impinging border of a median ventral plate.

FIG. 6. The inner surface of the major portion of fig. 7.

FIG. 8. The inner surface of the left anterior ventro-lateral plate of a third individual. a, b, c, and d, cross-sections of fig. 8, at right angles to the margin, at the points correspondingly lettered.

FIG. 9. The same as fig. 3, with the overlapping plates removed.

All the bones here figured were collected by Mr. J. Terrell from the Cleveland shale in Lorain and Huron counties, Ohio.

PRELIMINARY NOTICE OF A NEW SPECIES OF *TEMNOCYON* AND A NEW GENUS FROM THE JOHN DAY MIOCENE OF OREGON.

By JOHN EYERMAN, F. Z. S., F. G. S. A., Easton, Pa.

The collection made by the Princeton Scientific Expedition of 1889 in the John Day "bad lands" of Oregon contains, among many other interesting forms of Carnivora, an unusually large form of *Temnocyon*, quite distinct from those described by Prof. Cope in his *Tertiary Vertebrata*. Almost the entire skeleton is preserved. I am under many obligations to Dr. Scott for the free use of material from his magnificent collection, and still greater for very many valuable suggestions.

TEMNOCYON, Cope.

Talon of inferior sectorial trenchant; inferior molar 2 with trenchant crown and with *no internal cusps*.

T. altigenis, the type of this genus, is described by Cope in his *Tertiary Vertebrata* (vol. III, book I, p. 903).

TEMNOCYON FEROX, sp. nov.

Larger than the type species; cranium unusually well developed, being longer than in the type; palate curved and of less diameter than that of *T. altigenis;* small antero-posterior development of the true molars. Superior premolars equal in antero-posterior diameter to and greater in transverse diameter than in the type. Unusual development of cingulum on superior molar 1, and the position of superior molar 2 with reference to molar 1. In the inferior dentition, the weak development of premolar 4 in hight, and in the antero-posterior diameter as compared with the transverse. The small size of the metaconid of molar 1, and the regular contour of its crown.

HYPOTEMNODON, gen. nov.

Talon of inferior sectorial trenchant; internal cingulum greater and more pronounced than in *Temnocyon.* Inferior molar 2 tubercular, with *internal cusps* equalling in size those of the external side.

H. CORYPHÆUS Cope (*Temnocyon coryphæus* Cope). From the above it seems necessary to remove Cope's species, *T. coryphæus* (*Tert. Vert.*, vol. III, book I, pp. 906-912) from the genus *Temnocyon* and to erect a new genus to which is given the name *Hypotemnodon.* The specimen under consideration is the left ramus, collected by Dr. J. L. Wortman in the John Day "bad lands" and described by Prof. Cope in his *Tertiary Vertebrata* under the genus *Temnocyon.*

The above new species and new genus will be described more fully in a memoir now in course of preparation.

EDITORIAL COMMENT.

THE ORIGIN OF SPHEROIDAL BASALT.

The eruptive rocks of Point Bonita. F. LESLIE RANSOME. (Bulletin of the Department of Geology, University of Cal., vol. 1, pp. 71-114, Dec., 1893.)

The author presents a map of the region, which is the peninsula and point which, on the north, shut in a part of San Francisco bay and terminate on the north side of the "golden gate." The most of this area consists of the San Francisco sandstone, but along the western edge the country rises abruptly from the Pacific ocean, this elevation consisting of a ridge of basic eruptive rocks. These are terminated toward the east by a supposed fault which runs north and south but a short distance east of the ridge of eruptive rock. The ridge descends toward the north, ceasing at about four-fifths of a mile from the "golden gate."

The eruptive rocks show three facies in the field, which are also equally evident in making a microscopic examination. The author enumerates spheroidal basalt, pyroclastic rock and diabase. In a section through these parts the diabase is shown as rising highest, and as intrusive through the others,

the pyroclastic layer being above the spheroidal basalt. The diabase and the basalt, although they differ remarkably, are considered to be equally basic eruptive rock, the former cooling as an intrusive in older rocks and the latter as a surface flow. The pyroclastic stratum reposes upon an uneven surface of spheroidal basalt. It is composed of fragments of a light gray aphanitic amygdaloidal rock similar to that forming the spheroids below it, and ranging in size from the fraction of an inch to a foot or more in diameter, the average size being about three inches. "These fragments are finely comminuted volcanic ejectamenta. In general the fragments are more or less rounded, but sharply angular fragments are also abundant."

In the spheroidal basalt are some curious and interesting features. The large spherules are sometimes elongated, bale-like masses, whose longer axes are about parallel and extend obliquely downward. They sometimes weather out near the center, leaving a shell. They are amygdaloidal porphyritic, with feldspar, and in some cases the same rock embraces many fragments of red jasper. The interstices between the spheroids are filled with comminuted fragments of rock of the same kind, but decayed and crumbling, or with secondary products. In one case a block of sandstone four feet in diameter was seen resting partly imbedded in the volcanic rock. In thin section these spheroids display simply a uniform, finely crystalline, or porphyritic and amygdaloidal rock, composed of lath-shaped feldspars and a considerable proportion of glass, with secondary formation of much calcite and chlorite, and sometimes quartz. In the large spheroids the center is less amygdaloidal than the rest of the rock.

The author considers the evidence warrants the conclusion that the spheroidal portion of these rocks was ejected as a surface flow and that the rounded spheroids are an incident of flowage after ejection. The pyroclastic layer he regards as of the nature of volcanic ash, projected from a crater which was probably at some distance to seaward.

NOTE. This paper throws considerable light on some problematic features seen in connection with the greenstones of the Archean in the lake Superior region. It appertains to the spheroids and to the jaspers of the sandstones. Spheroidal

masses have been described by Lawson, Williams and Winchell in the oldest greenstones, and they have been referred respectively by them, to "concretionary structure," to brecciation and subsequent rubbing under "dynamic pressure," and to "agglomeratic accumulation" under the surface of the cotemporary ocean, in the near vicinity of an active volcano. Two of these theories require a surface origination of the rock, from volcanoes, and the other demands a plutonic, or deepseated, intrusive origin. It appears that, with the facts that Mr. Ransome gives, the superficial origin of such forms is proved, and it remains to determine whether the sea were present to receive the ejected material or whether it was evenly and rather slowly ejected upon a land surface and subsequently *flowed* in such manner as to produce these forms. Without calling in question here the close resemblance existing between these forms and the forms to which they are compared in the volcanic rocks of the Hawaiian islands, we desire to mention some considerations that seem to point toward the cotemporaneity of the "spheroidal basalt" and the jaspers of the San Francisco sandstone, and thus also indicating oceanic conditions for the accumulation of both.

1. The author considers that the San Francisco sandstone is separated into two parts, by the intervention of a bed of considerable thickness of jasper rock, called *phthanite* by Becker, showing that something affected the ocean in the vicinity of San Francisco bay which caused the rapid precipitation of silica, which at the same time was stained by a little iron. The author refers to various places, at a distance from San Francisco, where red jaspers also occur, saying "the rock [i. e., spheroidal basalt, N. H. W.] is always associated with the red jaspers, and with what is apparently the San Francisco sandstone" (p. 110), admitting that this association indicates "a contemporaneous rather than a subsequent origin for the basalt." (p. 109.)

2. The rock of the spheroidal basalt is found to contain, at least in one instance noted, blocks of sandstone four feet in diameter (p. 78) which shows that some force was in action which could rend and transport solid rock, and mingle the fragments with the spheroids. It may be questioned whether flowing lava could do it. Was the force volcanic explosion?

and was the fragment from the lower member of the San Francisco sandstone?

3. The bounding surfaces are perfectly sharp and definite "and entirely enclose each separate spheroid." It may be questioned whether flowage could thus entirely separate them from each other, for there seems to be no exception to their individual isolation. This rather indicates an individual history for each mass, involving separation from some parent mass, transportation to its present position and consolidation with its neighbors under the action of some later cementing agency. Had flowage produced these spheroids it is impossible that they would not somewhere show gradations into each other and finally into a simple lava sheet where they would be less and less distinct; the mass of the rock in general could not have so flowed everywhere in so uniform and yet so peculiar a fashion.

4. Judging from the descriptions the spheroidal basalt is not essentially different from the pyroclastic layer which overlies it. It seems to be allowable to suppose that they had a common origin, viz., as volcanic ejectamenta, the coarser bombs appearing in great profusion at the first eruption of the volcano, and the finer tuffs falling later. The lack of stratification in these deposits characteristic of oceanic agency may be due to the rapidity of the accumulation and the sheltered location of the volcanic area to the eastward of the vent where waves and currents could not readily act upon the debris, or it may be due to the fact that the debris fell upon a land surface instead of into the ocean, as presumed by Mr. Ransome. It is hardly possible, however, that at that place some of these materials, whether bombs or tuffs, should not have fallen into the ocean, and if the jaspers were deposited in the ocean on the eastern side of Point Bonita, as shown by their being embraced in the fragmental San Francisco sandstone, the tuffs at least may have fallen into the ocean over a large area and mingled with, or entirely displaced, the usual accumulation of that sandstone. If the phenomena here are comparable with the features that have been described in the greenstones of Minnesota, jasperoidal accumulations will be found intimately mingled with the tuffs and also closely

associated with the spheroidal basalt, being contemporaneous formations.

5. There are internal features ascribed to the spheroidal basalt which are apparently incompatible with the supposition that it was a surface flow of lava. (a) The spheroids are conspicuously porphyritic (p. 82) and the spaces between them are not, but are occupied by a secondary layer of impure calcite (p. 79) and chlorite. Had these forms been produced after eruption as a lava stream there would have been porphyritic crystals as frequent in the material filling the interstices as in the spheroids. (b) There is a zonal arrangement apparent in the spheroids (p. 82), and this indicates for each an individual, isolated history. This zonal arrangement began to be formed before the consolidation of the mass, since it caused a zonal distribution of the amygdaloidal structure. (c) Each spheroid seems therefore to have been independently under influences which not alone would produce amygdaloidal structure, but which operated on the surface of each in such a way as to distribute the amygdaloidal cavities most numerously about the periphery. When one considers the layering of igneous rocks due to successive eruption, and the succession of amygdaloidal beds between non-amygdaloidal and the fortuitous scattering of amygdules over the exposed surfaces of smaller lava layers, it is apparent that this zonal arrangement of amygdaloidal structure may have been formed by the contemporaneous exposure of each spheroid throughout its entire surface to a common cooling action. It seems very questionable whether such exposure could have been experienced when they were embraced in a common lava stream having a thickness perhaps of fifty to a hundred feet.

6. The general structural relations will allow the following successive steps in this history if the fault plane, which is assumed by the author rather than demonstrated, be discarded. (1) Deposition of the San Francisco sandstone, lower portion. (2) Eruption from a volcanic vent in the near vicinity, forming volcanic bombs, pyroclastic matter and finally molten lava streams. (3) The effect of this eruption was to substitute locally volcanic and chemical strata for strata formed by erosion. This area and this epoch of eruption may have been extensive. (4) Subsidence of the area affected be-

neath the sea and the deposition of the upper part of the San Francisco sandstone, thus bringing the upper member into contact with the diabase near the golden gate. N. H. W.

MARCH WEATHER ON THE GREENLAND ICE-SHEET.

Lieut. Peary started on the 6th of last March from his winter station on Bowdoin bay, near latitude 78°, with the plan of traveling northeast over the Greenland ice-sheet a distance of about 650 miles to Independence bay, the limit of his previous expedition, on the northeastern coast at latitude 82 . The party comprised 8 men, 12 sledges, and 90 dogs. Upon reaching Independence bay, which Peary hoped to do early in April, the party was to be divided for exploration both northward and southward. The time of his setting out, however, was much too early, being at the very beginning of the circumpolar half year of constant daylight. After a journey of two weeks on the ice-sheet, reaching an altitude of about 5,000 feet, the party experienced, on March 20th to the 23d, an "equinoctial storm" of blinding snow, fierce wind, and very low temperature, probably unequalled in the experience of any former Arctic expedition. The self-recording anemometer showed that the wind during thirty-four hours had an average velocity of 48 miles an hour; and the thermograph showed an average temperature of 50° F. below zero. Exceedingly cold weather and other very severe storms followed, the temperature being mostly 40° to 50° below zero, with almost continual wind. Some of the men had their feet and hands frozen; the dogs, enduring in the snow outside the tents the full hardships of the storms, were in a few instances frozen to death, and the others were attacked by a fatal disease; and some of the sledges were broken in being drawn over the sharply ridged snow drifts. The party was soon diminished to half its original number by the return of frost-bitten and sick men, until the expedition, after having advanced in total about 125 miles, was reluctantly abandoned by Peary on April 10th, that he might save a sufficient reserve of his provisions, sledges, and dogs, for another attempt next year. The summer was spent in explorations of the Greenland coast, glaciers, and border of the ice-sheet, in the neighborhood of the winter

station, and south to Melville bay. The intrepid Peary remains in Greenland with two comrades, intending again to attempt the same journey across the ice-sheet during the summer of 1895, with the hope of having considerable time for exploration on the eastern and northern coast. The severe weather found in the early spring indicates that travel on either the ice-sheet of Greenland or that of the Antarctic continent, where a distance of 850 miles lies between the most southern indentation of the shore line and the pole, will be practicable only during a few months in the middle and later part of the circumpolar summers. W. U.

National Representation in the International Congress of Geologists.

On this subject, in connection with the questions proposed by Mr. Frazer at the Zurich session (American Geologist for October, page 267), he spoke as follows:

M. le Président: La proposition que je viens de lire n'est presentée qu' à cette avant-dernière séance pour plusieurs raisons. D'abord comme tous ceux qui connaissent les travaux du Vice-Président actuel qui représente les Etats Unis à ce congrès, je ne saurais que féliciter ce dernier du choix admirable que l'on a fait de sa personne pour ce poste d'honneur. M. Ward mérite bien la distinction qui lui a eté decernée.

Ensuite il m'aurait été difficile de m'opposer à l'acte du conseil dans sa première séance où j'étais le seul membre présent accrédité aux Etats Unis sans courir le danger d'être mal compris. La question est beaucoup plus grave que ne le serait simplement le choix d'une personne quelconque pour servir comme officier de ce congrès. Pour la bien saisir, il importe de s'élever au dessus du niveau des ambitions et des préférences personelles, et pour mieux y réussir, je suis satisfait de la voir laissée aux mains du bureau afin qu'il puisse la resoudre à loisir et quand il lui conviendra, pourvu que sa décision soit donnée assez à temps pour la constitution du prochain conseil.

De cette manière la question perd tout lien avec la session actuelle, et ne concerne qu' exclusivement le bien du congrès dans l'avenir.

M. le Président, la raison d'être du congrès géologique, c'est la nécessité d'un tribunal scientifique international assez élevé pour ne pas être influencé par les conflits d'opinion et par les préjugés qui sont inséparables des organisations nationales.

Il n'y a pas de classe privilégiée dans la science, et ceux qui sont chargés de certaines fonctions et de certains travaux par un gouvernement ne sauraient prétendre à un privilége quecconque.

En dehors des sociétés savantes et corps relevant du gouvernement, il

existe dans chaque pays un grand nombre d'hommes qui se sont devoués à la science uniquement pour elle-même.

De ceux là viennent souvent les plus précieuses decouvertes, et, ce qui est encore plus important, ces géologues independants fournissent le seul contrôle dans leur pays des conclusions posées par les géologues officiels, et ce contrôle s'est souvent montré de la plus grande utilité pour le progrès de la science.

C'est pourquoi, si l' on accepte sans protestation le principe qu'une lettre du chef d'un bureau gouvernemental, presentée par un de ses employés au congrès international constitue un titre de membre *supérieur* en quelque sorte à celui que créent les travaux et les services des particuliers: si l'on déclare la représentation, dans le congrès, d'un bureau qui pourrait avoir intérêt à modeler à sa guise les arrêts du congrès en vue d'un but tout particulier, comme étant plus importante que celle des nombreux savants sans affiliation aucune: si, enfin, deux ou trois de ces employés, à l'insu du chef de l'État, ou même du ministre dont ils relévent, peuvent décider entre eux et sans consulter leurs confrères du même pays, quelle doit être la personne qui doit représenter le dit pays, je pretends formellement, si tout cela est permis, que le congrès loin d'offrir un asile à la vérité scientifique pure, risque de devenir un instrument pour consolider le pouvoir ou les doctrines de ces chefs de bureaux, et pour supprimer du même coup la liberté des géologues indépendants.

L'existence du congrès a eu toujours une influence entièrement salutaire sur les services nationaux, dont les chefs ont été forcés de respecter en lui le tribunal le plus élevé dans leur science. Il serait regrettable de ne pas laisser le congrès à ce rôle utile celui de gardien pour tous de la liberté scientifique absolue, c'est à dire en dehors de toute doctrine officielle et de toute pression administrative.

Mountain Systems of Asia and Europe.

Prof. Eduard Suess, of Vienna, has supplied a short abstract of his address before the International Congress of Geologists, as noted in our last number (page 263), of which the following is a translation:

The plicated mountains (falten Gebirge) of Asia are so arranged that they appear prominently in large curved masses (Bogenstücken) toward the south, and these marginal curves (Randbogen) also embrace Europe so that they reach from New Guinea to Gibraltar and to the Wadi Draa. The eastern curves of Asia, from Kamtschatka down to beyond the Philippines, are the similarly backward bent ends of the inner Asiatic chains, and are located behind the southern marginal curves. The whole of Asia, with the exception of the Indian peninsula, shows such a structure, produced in northern China, and to beyond lake Baikal, by very ancient, partly pre-Cambrian movements, but in other parts, for

instance, in the Thian-Shan, and along the marginal curve, for example, on the south flank of the Himalaya, by recent plication. The impression remains that, since pre-Cambrian time, the movements of Asia have had the same character, namely, that of flow, especially toward the south, but also toward the southwest, west, southeast and east, which reminds one of the flattening of the poles.

In Europe it is different. The oldest movements are represented by the pre-Devonian, Scottish and Scandinavian "floor" (Schuppe); there follows toward the south and east the Carboniferous and Permian floor-rim (Schuppenrand) with many later folds, and then the Miocene floor-rim of the Alps. The movements are also from a very ancient period in the same direction; but they are contrary to those of Asia, and have the character of confluence toward the north and especially toward the northwest. Here also recent movements (namely, the Alps) occur near the outside.

The similarity of the Asiatic movements in taking a general southerly direction, and of the European movements in being prevailingly northwestward, with their continuance in these directions during long geologic ages, indicates that these movements have been due to original heterogeneity of the earth's mass.

What we call *deformation* of the earth should be named *conformation*, namely, the gradual approach to a condition of equilibrium of weight as well as of form, which is as yet not fully reached.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Mesozoic Echinodermata of the United States. By W. B. CLARK. (U. S. Geol. Survey, Bulletin 97, pp. 207, with 50 plates, 1893. Price, 20 cents.) Sixty-one species are described here as the entire known Mesozoic fauna of this class in the United States. Fifty-one had been before described in many scattered publications, and ten appear for the first time. They include 5 crinoids, 4 asteroids, and 52 echinoids. All are well figured, and a full bibliography is given, making the work exceedingly convenient and valuable for paleontologists both at home and abroad. The author thinks that many South American echinoderms, though described under different names, are identical with the North American species; but he doubts that any European Mesozoic species are truly identical, and regards only a few as very closely allied. In this opinion he differs from Dr. J. W. Gregory, of the British Museum, who, reviewing the echinoid faunas of North and South America and the West Indies, and comparing them with the corresponding European faunas (Bulletin, Geol. Soc. Am., vol. III, for 1891, pp. 101-108), considers these two faunas on opposite sides of the Atlantic to have been

almost identical during the Urgonian and Aptian epochs of early Cretaceous time. Continuing into the Tertiary era, Dr. Gregory finds that the two faunas became widely and increasingly divergent, until in the Miocene and Pliocene periods intermigrations took place; and he regards these relations in the evolution of the echinoids of the two continents as incompatible with the theory of the permanence of the Atlantic ocean basin. But even without much change of the deep ocean, sufficient room for the early Cretaceous and later Tertiary migrations probably existed along the shores of the Färöe islands, Iceland and Greenland, during uplifts of these far northern regions and of the comparatively shallow intervening portions of the sea bed, by which the streams were enabled to cut the deep fjords. The culmination of the later uplift appears to have brought the cold climate and ice accumulation of the Glacial period, which was ended by the subsidence of these regions, partly drowning the fjords, and widely separating the islands that during late Tertiary and early Quaternary time probably almost united the northern parts of the continents. W. U.

Insect Fauna of the Rhode Island Coal Field. By S. H. SCUDDER. (U. S. Geol. Survey, Bulletin 101, pp. 27, with two plates, 1893. Price, 5 cents.) Fifteen species of insects, mostly cockroaches, are here described from the Rhode Island coal measures. All the species, and two of the six genera, are new. The earliest discovery of any of these fossils was by Rev. Edgar F. Clark. It is hoped that this publication will stimulate additional search in these strata and result in more extended discoveries. The two new genera are quite unlike any others in this country, but are rather allied to some that occur in the richly fossiliferous beds of Carboniferous age at Commentry, in France. W. U.

A Catalogue and Bibliography of North American Mesozoic Invertebrata. By C. B. BOYLE. (U. S. Geol. Survey, Bulletin 102, pp. 315, 1893. Price, 25 cents.) The first part of this work, filling 13 pages, is a list of authors, with titles, notes of the number of pages and plates under each and date of publication. Part II, filling the remainder of the volume, gives an alphabetic list of "all the names that have been applied to the genera and species of invertebrates obtained from North American rocks and referred by any author to the Mesozoic," with the place and date of their publication, the author, and the formation and locality or district where the fossils were obtained. W. U.

Historical Sketch of the Discovery of Mineral Deposits in the Lake Superior Region. By HORACE V. WINCHELL. (Pages 46; from the Second Annual Report of the Lake Superior Mining Institute, 1894.) The progress of the discovery of the valuable copper and iron deposits of northern Michigan, Wisconsin, and Minnesota, is here concisely reviewed from the time of the early Jesuit missionaries to the latest development, within the past four years, of the surprisingly rich Mesabi iron range. The explorations of Douglass Houghton, C. T. Jackson, Foster and Whitney,

Charles Whittlesey, I. A. Lapham, and later geologists, are shown to have given very important guidance toward the establishment of the present great mining industries of that region. A portion of this subject was presented to the readers of the AM. GEOLOGIST by Mr. Winchell in the last March number. The present memoir includes, in an appendix of eight pages, a useful bibliography of the history of mining on lake Superior. W. U.

Alaska: its Physical Geography. By ISRAEL C. RUSSELL. (Scottish Geographical Magazine, vol. x, pp. 393-413, with map; August, 1894.) Within the compass of twenty pages, Prof. Russell gives a bird's-eye view, as we may call it, of this extensive country, in which he explored the course of the Yukon river in 1889, and the district of Mt. St. Elias and the very instructive Malaspina glacier or ice-sheet during the summers of 1890 and 1891. The river systems, mountain ranges, volcanoes and hot springs, tundras, islands and ocean currents, glaciers, subsoil ice, the forests, the fauna, and the Eskimo and Indian tribes, are themes of successive portions of this essay. The finely colored map, on a scale of about 175 miles to an inch, shows the approximate area of forests, mostly below the altitude of 1,000 feet; of the tundras below the same 1,000 feet level; of the barren uplands; and of known glaciers, which occur along the southern coastal mountain ranges for a distance of 1,400 miles, from Sitka northwest to St. Elias, west to the Kenai peninsula, and southwest to Unimak island.

Describing the mountains, Prof. Russell writes: "The vast cordilleran system which follows the west coast of both South and North America traverses southern Alaska, and, bending westward, follows the coast to the end of the Alaskan peninsula. The partially submerged continuation of the same system forms the Aleutian islands, more than a thousand miles in length. The culminating points of this great system in North America are two rival peaks, Mt. Logan, 19,500 feet high, [*] and Mt. St. Elias, 18,010 feet high......In the neighbourhood of Mt. St. Elias the ranges are monoclinal, and agree in general structure with the Great Basin system more closely than with any other mountain type now known. In common with all lofty mountains, St. Elias is young. The foot-hills near the ocean have been elevated at least 5,000 feet during the existence of species of marine molluscs now living in the adjacent waters, and it is probable that the main uplift received an important increment at the time the foot-hills were raised above the sea. Since the mountains were uplifted, ordinary stream erosion seems to have had but little to do with their sculpturing; glaciers took possession of the depressions as soon as they were raised above the ocean, and the subsequent modifications of their forms have been largely due to ice-action." W. U.

Paleontology of Missouri, Part I. By CHARLES ROLLIN KEYES, State Geologist. (Missouri Geological Survey, vol. IV, 340 pp., 33 plates, 1 map.

[*The discovery and naming of Mt. Logan, with the determination of its altitude as the highest on this continent, were noted in the AM. GEOLOGIST for last April, p. 292.—EDS.]

Jefferson City, 1894. The first installment of the report on the fossils of Missouri is a thick volume of some 250 pages, besides 30 plates and a large geological map of the state. The work shows a marked, as well as happy, departure from most official reports on the subject. Instead of devoting all energies towards multiplying species and giving long, detailed descriptions of the fossils, Dr. Keyes has attempted, and very successfully, too, to make it the foundation of a broad stratigraphic study of the entire Mississippi basin and a guide to the future development of mineral wealth, thereby giving the report an economic twist. The work is fourfold in its character. Briefly, it comprises (1) An index to the fossils of the state, through means of which the forms now known to occur within the limits of the region under consideration may be recognized readily without recourse to great libraries; (2) a bibliography of Missouri palæontology, bringing together all that has been written on the subject, now so widely scattered and practically inaccessible; (3) a summary of what has been done up to the present time in this branch of science, in so far as it pertains to the state of Missouri; and (4) an introduction to more comprehensive faunal studies, tending toward a solution of stratigraphical problems at present more or less obscure.

The general plan of treatment of the different species enumerated has been to give under each a more or less complete bibliography, by reference to which additional information or good illustrations of the forms not here figured may be found. In the diagnoses it has been the aim to give a rather full description of some leading representative of each genus, accompanied by a suitable figure, and to make the sketches of the other members of the group brief and in a great measure comparative. By this manner of dealing with the subject it is thought that the characterizations of all the species would be sufficiently ample for intelligent comprehension and for the particular uses to which the work will be put. At the same time, the bulk of the report was reduced very greatly—to one-fourth, at least, of what it would otherwise have been. The horizon and some of the leading localities of each species are also given. The matter of localization has had to be rather general, allusion being made to the nearest postoffice usually, or in a few instances, as when the fossil is common and the distribution wide, merely to the county. With the greater portion of the material the exact bed, with reference to a particular section, has not been made known.

It is astonishing what a vast array of fossils is represented in Missouri, and this state must certainly be one of the most favored provinces in all the great Mississippi basin for the study of ancient forms of life. The wide range of geological formations present, from the Cambrian to the top of the Paleozoic, makes the record exceptionally complete, probably more so than in any state of the great interior basin.

Something of the vastness of the present undertaking may be inferred when it is learned that in the two volumes on the subject—the second, it is understood, will be issued in the course of a few weeks—there is condensed material which if it were written up after the manner of the

Illinois reports, for example, would probably exceed in size the nine large volumes of that state.

On account of their varying value for classificatory purposes, the treatment of the different zoological groups has not been the same. In order to carry out the main intent of the work, and still have it included within the limits originally planned, it has been necessary to condense greatly the consideration of many of the sections. The most characteristic forms of the various geological horizons, and the species which are little known, have been considered more in detail than other forms equally interesting and perhaps even more important. Certain large groups have consequently been very briefly alluded to. Such are the polyzoans, vertebrates, and various sections of lower taxonomic rank.

Accompanying the paleontological portion of the report is an introduction of nearly 100 pages, on the general stratigraphy of the state, which contains much new information.

The illustrations are largely zinc etchings, and for their kind could scarcely be excelled. They are works of art, perfectly clear in every detail, and entirely free from that "muddiness" which is almost always apparent in work of this kind. The drawings were chiefly the work of Dr. McConnel, of Washington, D. C., of M. Westergren, who for thirty years was draughtsman in the National Museum of Sweden, and of the author. H. F. B.

The Lower Silurian Ostracoda of Minnesota. By E. O. ULRICH. (Chapter VII of vol. III. Final Report, Geological and Natural History Survey of Minnesota, July, 1894, pp. 629-693, pls. xliii-xlvi.) The crustacean order Ostracoda attracts but few paleontologists, although their remains appear to be as abundant as the trilobites. This lack of interest is probably due to the usually small size of the carapace of these animals, though some Silurian and Cambrian species have a length of nearly two inches. Geologically younger specimens never attain anything like this size. Miller in his "North American Geology and Paleontology, 1889," catalogues one hundred and twenty-seven species in eleven genera. In 1890 Mr. Ulrich described or identified ninety-eight additional species and twenty-one genera. In the present work fifty-four species and seven genera more are added, making in all about two hundred and eighty-five American species of Paleozoic ostracods distributed in forty genera, a growth since 1890 doubling the known species and nearly quadrupling the genera. Collectors will do well to give attention to washing shale and other soft friable strata and thereby obtain many forms of Ostracoda, Bryozoa, and the younger stages of Brachiopoda, Mollusca, Crustacea, etc.

In this chapter are described sixty-eight species, of which fifty-four are new. These are grouped under twenty-two genera, of which *Leperditella*, *Primitiella*, *Dicranella*, *Dilobella*, *Ceratopsis*, *Macronotella* and *Krausella* are new.

"In the Lower Silurian deposits Ostracoda occur in such great numbers and variety, that it is doubtful if the representation of the order at

any subsequent time exceeded them in these respects. The predominant types, *Leperditiidæ* and *Beyrichiidæ*, moreover, after holding their own perhaps through the Upper Silurian, were greatly reduced during Devonian and Carboniferous times and are now totally extinct. Some recent families and genera, on the other hand, are sparingly represented, but, taken as a whole, the Silurian Ostracoda fauna is decidedly peculiar.

"The Ostracoda are everywhere poorly represented in the Triassic and Jurassic. But in the Cretaceous and Tertiary strata of Europe certain genera, *Cythere* especially, develop an astounding variety and wealth of species. The forms are all small, and this may in part account for the fact that so few have been discovered in American deposits of these ages." C. S.

Eléments de Paléontologie. Par FELIX BERNARD; *seconde partie* (pp. 529-1,168) *avec 251 figures dans le texte.* Paris. Baillière et fils, 1895. The reader is referred to vol. XI, p. 410, AMERICAN GEOLOGIST, for a notice of the first part of this work. With this part the volume is closed. Although it is especially addressed to French scientists, in whose literature it certainly must constitute a valuable contribution to the philosophy of paleontology, it will be closely scanned by many in other countries who may be seeking for a concise presentation of the evolutionary steps and the structural relations through which life upon the globe has passed to its present stages. The author's chief aim is to exemplify the relations of paleontology to the biological sciences, rather than to set forth the special characters of numerous species or genera. He dwells, therefore, on the morphology and the internal structures and on the embryological development of fossil forms. The march of life, therefore, as presented is a grand panorama of evolution. The work covers both animal and vegetable paleontology. It is sp[illegible]y full in the discussion of the mammifers and reptiles, and man[illegible]ican discoveries in the development of these classes, are credi[illegible] Cope and Marsh. With this exception recent American paleo[illegible] work is not so fully recognized [illegible] N. W.

Principes et Méthodes d'étude de Corrélation au moyen [illegible] Fossiles. By LESTER F. WARD. Congrès Géologique Intern[illegible] Compte Rendu de la 5me Session, Washington, 1891 (published [illegible] 109. This paper admits fully the view propounded by Hu[illegible] successive floras of different regions should be regarded a[illegible] rather [illegible] contemporaneous, that is to say, their contem[illegible] should be [illegible] ated rather by their general aspect than by [illegible] Following this principle, Prof. Ward lays d[illegible] paleobotany [illegible]

but now proved by David White, on the evidence of a large collection of plants, to be Middle Cretaceous.

Prof. Ward next discusses the influence of geographical distance in lessening the identity of species in floras while the general aspect of resemblance continues. Contemporaneity of date may be inferred from identity of species, especially in the more recent and not geographically remote strata; yet as we recede to a greater distance the forms are extinct and their exact relationship is difficult of determination, especially among the cryptogams. Hence more stress must be laid on close alliance than on identity, because the latter is frequently a matter of opinion of the palæontologist. The essay is a valuable contribution to exactness in this department of geology. E. W. C.

Fossil Plants as an aid to Geology. By F. H. KNOWLTON. Journal of Geology, vol. II, pp. 365-382; May-June, 1894. Prof. Knowlton takes up the same points as the foregoing paper and quotes largely from it regarding the use of plant fossils in the widest sense. As to their value in a more restricted area, he cites the remarkable case of the Dakota group which has yielded 460 species of plants, with only ten invertebrate and no vertebrate fossils. Of the plants 394 species are peculiar to that horizon, and many of these are so characteristic as to settle any question of the age of other beds in which they occur. As an instance of this, the author quotes the mistaken reference of a so-called specimen of *Sterculia drakeii* from the Big Tucumcari beds of New Mexico as the only known dicotyledon from the Trinity sands of the Comanche series. It is, he says, *Sterculia snowii* of the Dakota group and at once determines the age of the stratum in which it is found. Several other instances are given of the importance of plants in determining the age of Cretaceous strata in the west, such as the Colorado and Middle Park or Denver beds, the Livingston beds, and the Great Falls beds in Montana. Economically, Prof. Knowlton shows the value of palæobotany in quoting the case in which Zeiller predicted the discovery of a bed of coal in France on palæobotanical grounds. A shaft was sunk, and at the depth of nearly 2,400 feet coal was found, having a thickness of about fifteen feet.

In writing of fossil plants as a test of climate, the author says, "the absence of rings of growth in the Carboniferous conifers shows, as long ago pointed out by Witham, that the seasons, if such they could have been called, were either absent or not abrupt." With this view it is not quite easy to coincide, because, not to discuss here the somewhat doubtful case of conifers, there were undoubtedly other Carboniferous plants whose remains exhibit distinct rings of growth.

In conclusion the author justly remonstrates against the too frequent practice of expecting the palæobotanist to determine mere fragments of plants uncritically collected and ill preserved. As well might a botanist be called on to name scraps of living plants badly dried and sundered from each other. In both cases the task is often impossible or the result is useless. E. W. C.

The Post-Pliocene Diastrophism of the Coast of southern California. By

ANDREW C. LAWSON. University of California, Bulletin of the Department of Geology, vol. I, pp. 115-160, with two plates and a section; Dec., 1893. The term *diastrophism*, proposed by Powell for the collective processess of deformation of the earth's crust, includes *orogeny* (mountain-making) and *epeirogeny* (continent-making). The last of these terms, as proposed and defined by Gilbert, embraces the uplifts and subsidences of large areas producing continents and plateaus, ocean beds and continental basins. Both these classes of orogenic and epeirogenic earth-movements have produced important changes on the Californian coast since the beginning of the Quaternary era.

Marine wave-cut terraces of post-Pliocene age are described by Dr. Lawson in this paper at numerous places along the distance of 450 miles from San Francisco southward to San Diego, near the Mexican boundary. They show an epeirogenic uplift of these parts of the coast (and the author thinks the upward movement to have been continuous for all this distance), during post-Pliocene time, to an extent of from 800 to 1,500 feet. In the vicinity of San Diego the successive terraces marking stages in the emergence of the land are approximately 800 feet, 700, 600, 520, 340, and 160 feet above the sea. Pleistocene marine fossils have been collected there by Dall at the altitude of 600 feet and twelve miles distant from the sea. At San Pedro hill, a projecting point of the coast about 100 miles northwest of San Diego, the appproximate altitudes of the old shore lines are 1,240, 1,040, 960, 860, 700, 550, 400, 300, 240, 160, and 120 feet. The terrace at 1,240 feet has abundant waterworn gravel; and the limestone of this shore, as of several others lower, displays plentiful borings made by lithodomous mollusks. On San Clemente island, about 75 miles west of San Diego, twenty-two terraces were noted, the highest being 1,500 feet above the sea. Santa Catalina island, however, lying midway between San Clemente and the San Pedro headland, shows no such elevated strand lines and appears even to have been sinking while the areas south and north of it were rising. Probably other islands of this group also stood higher than now and even had connection with similarly higher adjacent portions of the mainland during late Tertiary and early Quaternary time, as Le Conte concludes for Santa Rosa from the occurrence of elephant bones on that island and for Santa Cruz from peculiarities of its flora. These islands lie opposite to Santa Barbara and are about 100 miles northwest of those examined by Dr. Lawson, whose opinion that all the coast shared in the Pleistocene uplift needs therefore to be tested by further exploration, especially through Santa Barbara county.

At Carmelo bay, 300 miles northwest of San Clemente and Santa Catalina, and about 80 miles south of San Francisco, abundant evidences of post-Pliocene submergence and re-elevation are again found up to the hight of 800 feet, as noted by Dr. Lawson in pages 46-57 of the same volume. Some 30 miles farther north, in the vicinity of the town of Santa Cruz and westward along the north coast of the bay of Monterey, nine terraces were observed, the highest being at 1,200 feet.

Besides the epeirogenic movements which are thus ascertained, a re-

markable Quaternary orogenic disturbance has uplifted and steeply tilted the thick Merced series of richly fossiliferous Pliocene sandstone strata on the peninsula of San Francisco, a few miles south of the Golden Gate. The center and cause of the disturbed area is the Montara mountain, an upthrust portion of the granite floor on which the Mesozoic and Pliocene beds had been deposited. The latest and chief uplift of Montara mountain took place at the end of the Pliocene and during Pleistocene time, which also, according to Turner, included the similar upthrust of Mount Diablo, about 25 miles east-northeast of San Francisco; and on the other side of the great valley of California, according to Le Conte, Diller, Becker and others, the extensive faulting and tilting which produced the present high Sierra Nevada range belonged to the same period. Dr. Lawson thinks that a part of the area of the Merced series had sunk to the vertical extent of more than a mile, the measured thickness of the series, during its deposition. Its basal beds now outcrop at the altitude of 700 feet above the sea, indicating an equally great re-elevation. But if this series comprised the outwardly dipping beds of an advancing delta brought by the Pliocene representatives of the Sacramento and San Joaquin rivers, as Shaler has suggested for the similarly extensive section of inclined strata at Gay Head, Martha's Vineyard, the required subsidence and ensuing upward movement would be reduced to moderate amounts.

The time of the depression of large portions of the coast and some of the islands southward to San Diego is referred by the author to the Pliocene period, and that of their uplift to the Pleistocene, the division between the Tertiary and Quaternary eras being marked by a general reversal in the epeirogenic movements of this coastal region. The upward movement seems to have been closely related to the much greater uplift occurring farther north, which extended from the Pacific to the Arctic and Atlantic coasts and at its culmination caused the accumulation of the North American ice-sheet. The Pliocene depression near the Golden Gate permitting the deposition of the Merced series seems to have been contemporaneous with a somewhat greater elevation than now back from the coast, since the rivers would need more than their present slopes for transportation of the sands forming the Merced strata. It is further evident that the Pleistocene upheaval at its culmination raised the coast on the latitude of San Francisco at least 414 feet above its present hight, as shown by the depth of the channel at the narrowest part of the Golden Gate, and by the eroded lower portion of the tributary valley now occupied by the San Francisco and San Pablo bays. A much greater vertical extent of this uplift, however, seems to have been attained and held during a time sufficient for the erosion of the deeply submerged valleys on this continental slope, which have been made known by Davidson and Le Conte, reaching to a depth of 2,000 to 3,120 feet where they cross the general submarine contour line of 600 feet below the sea level. The channeling of these valleys or cañons on a high coast, with plentiful rainfall, may have been very rapid and sometimes independent of any connection with important valleys of the

streams now existing. To that time of very high but geologically brief Pleistocene uplift we may refer the passage of the mammoth from the continent to Santa Rosa island, if it should be found that the preceding Pliocene submergence affected the entire coast line. W. U.

Notes on the Pleistocene of the Northwest Territories of Canada, northwest and west of Hudson Bay. By J. BURR TYRRELL. Geological Magazine, IV, vol. I, pp. 394-399, with map; Sept., 1894. In the years 1892 and 1893 Mr. Tyrrell, for the Geological Survey of Canada, explored a large region from the Churchill river and lake Athabasca northeastward to Chesterfield inlet and Hudson bay. A preliminary account of his exploration in 1893, from which he returned along the west coast of Hudson bay, was given in the AMERICAN GEOLOGIST last February (page 132). In the present short paper Mr. Tyrrell notes the occurrence of horizontal red sandstones and conglomerates, cut by trap dikes, similar lithologically with the Keweenawan series of the lake Superior region and probably of the same age, south of Athabasca and Black lakes and from Doobaunt lake (lat. 62° 30′ to 63° 30′, and long. 101° to 102° 30′, with an altitude about 500 feet above the sea) northeast and east to the head of Chesterfield inlet. Laurentian gneiss borders the north side of lake Athabasca, reaches thence northeast to Doobaunt lake, and again appears along the north side of Chesterfield inlet. For 150 miles south of this inlet the greater part of the northwest shore of Hudson bay was found to consist of "green Huronian schists cut by many quartz veins, and sprinkled through with particles of copper pyrites."

The whole region has been strongly glaciated, and the directions of the currents of the ice-sheet were noted in hundreds of places. On the upper Churchill river the glacial movement was prevailingly south or a little west of south; about lake Athabasca, Black and Daly lakes, and along the Telzoa river to Doobaunt lake, west; about the north part of Doobaunt lake and along the next 150 miles of the Telzoa river in its course through Wharton, Aberdeen, and Schultz lakes, northwest; but on Baker lake, next southeast of Schultz lake, and along Chesterfield inlet, south to southeast; along the northwest coast of Hudson bay, also southeast; and in the vicinity of Fort Churchill, at the mouth of the Churchill river, three sets of striæ were observed, respectively (1) S. 5° W. to S. 10° E., (2) N. 80° E., and (3) N. 55° E.

The southward striation at Fort Churchill is preserved on the summits and northern sides of the hills, and Mr. Tyrrell supposes it to be the most recent of the three courses; but it may be questioned whether it is not more probably the oldest, being possibly as early as the time of maximum thickness and extension of the ice-sheet. The northeastward striation would then be referable to the time of departure of the ice, when the land was depressed from its great preglacial elevation, so that the sea coming into the areas of Hudson strait and bay melted away the ice-sheet there faster than over the land areas on each side. This melting appears to have opened a large embayment or basin into the central part of the originally ice-covered area, and to have finally turned the

glacial currents at Fort Churchill northeastward, in a nearly opposite direction to the former course held during the greater part of the Ice age. If the total glacial erosion, besides plowing up the preglacial stream deposits and general mantle of residuary clay, removed also on the average several or many feet from the underlying rock surface, it is evident that nearly all the striæ produced during the early and middle portions of the Glacial period were erased and their places taken by later markings. The ice-currents recorded by Mr. Tyrrell radiating in all directions outward from the region west of Hudson bay and east of the Telzoa river therefore probably are referable to a late stage of the glaciation, when the previously thick part of the ice-sheet covering the basin of Hudson bay had been melted, on account of the ingress of the sea, more rapidly than its portions at the west and at the east and southeast, which consequently for a time flowed into the Hudson bay area, engraving the latest and most plentiful courses of striation.

An opinion here stated by Mr. Tyrrell, that Hudson bay was an inland sea during the Ice age, thus appears to be true only for its closing or Champlain epoch. The northeastward and eastward glacial striæ recorded by Bell on the northeastern shores of this great bay and along Hudson strait, with the extension of the ice-sheet thence eastward beyond the present coast of Labrador, and its extension west and northwest, as shown by Russell, Dawson, and McConnell, to the upper part of the Yukon basin and beyond the lower course of the Mackenzie river, indicate that the area of Hudson bay during the greater part of the Glacial period was enveloped by a deep ice-sheet, which, because of its thickness and the hight of its surface in that central portion, outflowed east into Davis strait and the North Atlantic ocean, south and southwest to the Ohio and Missouri rivers, and northwest to the Arctic ocean north of the mouth of the Mackenzie. Due south of Hudson bay the ice-sheet had its greatest extent in the United States, reaching in southern Illinois 200 miles farther south than in New York and New England. Drift from east of Hudson bay also was carried far southwestward. Boulders of a peculiar rock formation which occurs in place, so far as known, only on the east coast of this bay where it narrows into James bay, are plentiful in the drift southwest of James bay and continue to North Dakota and southern Minnesota, 1,000 miles from their outcrops.

Drumlins or ridges of till, and eskers or ridges of sand and gravel, were commonly found, throughout the region traversed by Mr. Tyrrell, on the areas having a considerable average thickness of drift deposits; but some tracts, as the shores of Chesterfield inlet and part of the northwest coast of Hudson bay, are largely bare rock. The eskers often were observed to extend long distances, "parallel to the glacial striæ, over hills and through valleys and lakes, quite regardless of the surface contour of the country."

Strand lines of the Late Glacial or Champlain marine submergence were seen along all the lower part of the Telzoa river, the first and highest being about 400 feet above the present sea level. Near Fort Churchill,

however, the uprise of the land seems to have ceased or to have been very slow for at least 150 years, as shown by inscriptions cut on a precipitous rock shore there by sailors as early as 1741, 1746, 1753 and onward. W. U.

PERSONAL AND SCIENTIFIC NEWS.

PROF. CHARLES S. PROSSER, of Washington college, Kansas, has been appointed to the chair of geology at Union college, Schenectady, N. Y.

GEN. WILLIAM W. DUFFIELD, of Detroit, has been appointed by the president to succeed Prof. T. C. Mendenhall, resigned, as superintendent of the U. S. Coast and Geodetic Survey.

MAJOR C. L. GRIESBACH, after about twenty years service in the Geological Survey of India, is appointed to succeed Dr. William King as director of that survey.

THE CONSTANTINOPLE EARTHQUAKE OF JULY 10, 1894, transmitted its earth pulsations as far westward as to Kew, England. An investigation of their velocity by Prof. Charles Davison (in *Nature* for Sept. 6) shows that this distance of 2,500 kilometers was traversed in 780 seconds, at the average rate of 3.23 kilometers, or about two miles, per second. To Utrecht, in Holland, nearly 2,200 kilometers, the rate of progress of this earth wave per second was 4.05 kilometers, or two and a half miles. In general the progress to nearer points was not more rapid proportionally than for these greater distances. The speed of transmission of the earthquake at Charleston, S. C., August 31, 1886, felt 800 to 900 miles north and northwest in New England, New York, Wisconsin, and Iowa, was found by Dutton to be about three miles per second.

THE GEOLOGICAL MAP OF EUROPE, which has been under course of preparation by a committee of the International Congress of Geologists since 1881, contains 49 sheets, of which six are now ready for issue, including Scandinavia, northern Germany, and parts of France, Belgium and Poland. It is expected that the next ten sheets will be issued within a year, to include the British Isles, France, Spain and Portugal, Italy, and Switzerland. In the drift-covered area of northern and northwestern Europe, the bed-rocks, where their distribution is known, will be shown by thin bands of color over the colors for the Quaternary formations. The subscription price for the entire map is $20, but this may be paid in instalments as the successive parts are issued, the proportion for the first part being $2.50. Subscriptions must be sent to Dietrich Reimer, Berlin, before the close of this year, after which the price will be increased.—*Nature*, Sept. 20.

John Locke

THE AMERICAN GEOLOGIST.
Vol. XIV, Plate X.

THE

AMERICAN GEOLOGIST.

VOL. XIV. DECEMBER, 1894. No. 6.

SKETCH OF DR. JOHN LOCKE.

By N. H. WINCHELL, Minneapolis, Minn.

(Plate X, Portrait.)

Fifty years ago the person of John Locke, of Cincinnati, was a familiar object to the higher circles of science in that city. No less familiar to the geologists of fifty years ago was the personality of his genius and the power of his industrious pen. As a geologist, however, his career was short. He returned to the medical profession, and secondarily to physics and astronomy. His chief laurels will always be found in the contributions which he made to other sciences, yet as an original contributor to geology he was associated with Owen, Hall, Shumard, Whittlesey and Foster.

Born Feb. 19, 1792, at Lempster, N. H., he spent his boyhood at Bethel, Maine, where his father was proprietor of "Locke's mills," still known.* Here he took much interest in the machinery of the mill and in the physical problems involved, exhibiting a precociousness which marked him throughout his early career, and which took the direction of mathematics and natural science. He became greatly interested in botany, and published a text book which was ad-

*The writer is under obligations to Mr. J. B. Locke, of Zumbrota, Minn., nephew of Dr. John Locke, for much information concerning the personal history and character of Dr. John Locke, and for the use of a copy of the memorial address of Dr. M. B. Wright, delivered at the request of the Cincinnati Medical Society. There is also an account of Dr. Locke in the "History of Bethel, Me.," published in 1891, by Dr. Wm. B. Lapham. Col. Chas. Whittlesey also gave a brief, appreciative sketch of him in the Magazine of Western History. 1885, p. 84. In the Am. Jour. Sci. (2), xxii. p. 301, is a brief obituary notice, of thirteen lines. There is also a sketch in the "Locke genealogy," Boston, 1853.

mired for the simplicity of its arrangement. At Bridgton he made the acquaintance of Seba Smith, author of the "Jack Downing letters." He was turned from the effort to procure a collegiate education because the ordinary college course in those days comprised little that was practical, and embraced mainly those studies in which he had no interest. He chose medicine; and was for a short time at Dartmouth college, but took his degree at Yale, to which place he was attracted by reading "Silliman's Travels in Europe." Resigning a position in the navy because of the unwholesome sanitary conditions which he noticed on shipboard, he returned to New Haven, where he had established a reputation for industry, energy and ability.

Scarcely four years had elapsed since he left the valley of the Androscoggin. He had taught botany at Keene, N. H., had been appointed, through the friendly influence of Prof. Bigelow of Boston, procurator of plants for the botanical garden of Cambridge, under the patronage of the Massachusetts Agricultural Society, had delivered public lectures at Portland, Maine, botanical lectures at Dartmouth college and at several academies, had issued a popular scientific work and had become a doctor of medicine. All this was accomplished without one dollar of patronage or support, except that created by his own exertions. His father, although not destitute of means nor of intelligence, could not fathom his designs nor appreciate the tendency of his labors sufficiently to induce any pecuniary outlay. He reasoned: "If the boy can summon courage enough to appear before learned men and by his unaided efforts has acquired knowledge enough to impart to them instruction, he needs no assistance from me; his own will seems destined to achieve that which money cannot purchase."

He then made an unsuccessful attempt to establish himself as a physician, but resorted to teaching, in a female academy at Windsor, Vt. as assistant to Col. Dunham, who subsequently removed to Lexington, Ky. It was through this connection that Dr. Locke was induced to coöperate in the establishment of a new school, at Lexington, in which he bore the principal part, Col. Dunham having been unexpectedly detained. In 1822 Dr. Locke left Lexington, for Cincinnati,

which he determined to make his abode for life. He established immediately a new school, long known by its high reputation, in which many of the present mothers of Cincinnati were his pupils. He was among the earliest instructors and lecturers in Mechanics' Institute, but the young mechanics went to his private apartments for instruction. He particularly excelled in making clear to his listeners the principles of chemistry and physics. They were inspired and attracted by his enthusiasm. He made with his own hand many of the instruments which he needed.

In 1835 Dr. Locke was elected professor of chemistry in the Medical College of Ohio, and he entered upon his duties with the zeal of one having no thought of failure. He had been liberally patronized, and had been successful as a teacher. His associations had been adapted to his sensitive nature. All around were daughters, wives and mothers, sustaining by their intelligence and accomplishments his self-made reputation. But his desire for more ample scope for the study of scientific problems induced him to sever the pleasant and remunerative relations which he had sustained for thirteen years.

The chemical department he found nearly destitute of everything needed for illustration. His own handicraft supplied many pieces of apparatus, but he finally visited Europe in 1837, for the purchase of much more. The college rapidly rose in reputation and patronage, largely due to the renown which was spread abroad from the energy and popularity of the department of chemistry. We will not, however, pursue the course which Dr. Locke carried out in that institution, nor dwell upon his magnetical or astronomical researches, some of which proved of the greatest value to science. The chief of these was his "electro-chronograph," or "magnetic clock," which was pronounced by Lieut. Maury, of the National Observatory, Washington, an invention of the highest value to the Coast Survey, "a national triumph, belonging to that class of achievements by which the most beautiful and enduring monuments are erected to national honor and greatness." For this signal triumph congress voted him $10,000 in 1849, and the English government presented him a full set of magneti-

cal instruments. He also invented a "microscopic compass," and an instrument known to geologists as "Locke's Level."

It was while he was absent in Europe, in 1837, that he was appointed one of the assistants on the Ohio survey under W. W. Mather, then just established. He took no part in it the first year. But his report for 1838 is probably the most valuable contribution to the geology of Ohio which was made through that survey, by any single man. It is the most voluminous and the best illustrated. Prof. Orton, who again examined, for the second survey, the region on which Dr. Locke reported (S. W. Ohio), had occasion repeatedly to commend at once the scope and the detail of Locke's first report, saying that he had found it correct in observation and in generalization. It gives one of the first expositions of the "Blue limestone," bringing out clearly the anticlinal form of the gentle dips observable along the Ohio river, and showing that the coal beds of eastern Ohio, on one side, and of Indiana on the other, could not possibly exist in the region of Cincinnati except high in the air, at 1,160 feet above Adams county. He gives, in connection with a colored map of Adams county, a perpendicular colored section of the strata from the coal and conglomerate of Scioto county on the east, to the west line of Adams county, supposed to pass through West Union. Here he represents the Waverly sandstone at the east line of the county, 343 feet thick; followed by a bituminous slate, containing conspicuous septaria, now known as the Huron shale, of Devonian age, 251 feet thick; Cliff limestone, with basins of iron ore, involving in this both the Devonian and Upper Silurian limestones, 89 feet thick; marl, 106 feet thick, probably Upper Silurian, flinty limestone, 51 feet; clay marl, 25 feet, and Blue limestone, 1,000 feet. Although the structure of the region is well made out, there is no attempt to assign the strata to their respective ages by comparisons with other states or with Europe. He made an excursion into the coal regions of the southeastern part of the state, and another under the guidance of Dr. D. D. Owen, to Madison, Ind., for the purpose of comparative study of the stratigraphy, particularly to determine the manner of junction of the Cliff limestone with the Blue. On the latter excursion he remarks: "For the information of those who may be inclined to make the investiga-

tion, permit me to observe that I shall not charge the State of Ohio my salary during this excursion beyond its limits, but as a sketch of the information would, I thought, serve to show the connection of our geological formations with those of an adjacent state, I have taken the liberty of offering it to the service of our citizens." (p. 238).

In this report he described and figured *Isotelus maximus* (which he afterward changed to *Isotelus megistos*), comparing it accurately with *Isotelus megalops* Green. His specimen was 21 inches long, its great size being the only definable difference which he could discover between it and Green's *I. megalops*, which was 5 inches long. He feared his specimen might be "actually an overgrown *megalops* of Green." He made also a careful examination and illustration of certain peculiar "diluvial grooves" which he found seven miles above Dayton, on the limestone of Light's quarry, in Montgomery county. He compares them with grooves described by Dr. Hitchcock on the Primitive rocks of Massachusetts, and suggests that they may be due to icebergs floating over the terrace. "The rectilinear course of these grooves corresponds with the motions of an immense body, the momentum of which does not allow it to change its course upon slight resistances." The glacier hypothesis of professor L. Agassiz had not then been heard of in America.

The "first survey" of Ohio was discontinued because of the failure of the Legislature to make the necessary appropriations of money; indeed, the second year's work, and the most valuable portion of the report published in 1838, resulted from the unexpended surplus of the funds appropriated for 1837. The survey was well begun and ably maintained, but its utility was not appreciated.

The following year (1839) Dr. Locke was in the service of the United States government under Dr. D. D. Owen in the survey of the "Mineral Lands of the United States." It shows how little conception of the mineral wealth of the United States the government then entertained, to observe that such lands were defined as "all the lands in the Mineral Point and Galena districts which are situated south of the Wisconsin and north of the Rock river, and west of the line dividing ranges eight and nine east of the fourth principal meridian,

together with all the surveyed lands in the Dubuque district," and that a report thereon was required "before the approaching winter should set in."* Here Dr. Locke was entrusted with the "physical department" of the survey, as noted by himself, which he understood to include, especially, the barometrical observations, the measured altitudes and the geological sections. The report rendered by him† has the following parts:

1. A comparison between the rocks of the lead or mineral region and those of Ohio, Indiana and Kentucky, called the "Cliff limestone," showing their probable identity.

2. Several sections of strata (the hight and thickness being determined by the barometer) with drawings.

3. The altitudes of table lands, hills, mounds and mountains, determined by barometrical observations, with a chart.

4. The result of numerous observations and calculations on the elements of terrestrial magnetism, including the dip, declination and force or intensity of the magnetic needle at several places between Cincinnati and the region surveyed, and in that region itself, accompanied by two charts; together with some remarks on the practical uses of these elements of magnetism.

5. Surveys of a few of the earthwork antiquities of Wisconsin, with drawings.

6. Some observations on the climate and meteorology of the upper Mississippi.

7. Acknowledgments and concluding remarks.

The lead-bearing limestone of the upper Mississippi valley he considered older than the coal-bearing rocks, arguing at some length to prove that Keating's idea of their super-Carboniferous position was erroneous, and that they were the equivalent of the Cliff limestone of Ohio. He gives colored sections from the south fork of the Little Maquoketa to Sinsinewa mound, and across the Mississippi at Prairie du Chien. The former shows only the Cliff limestone, 550 feet in thickness, abounding in veins of lead ore, and the Blue limestone somewhat below water-level. The latter represents the Blue limestone about 400 feet above the river, 115 feet thick, underlain by the Buff limestone 20 feet thick, which rests on a soft sugar-like sandstone 40 feet thick. Magnesian lime-

*Report of Dr. Owen dated Jan. 20, 1840.

†Report of John Locke, M. D., to David Dale Owen, M. D., principal agent to explore the mineral lands of the United States. Included in Dr. Owen's report ordered to be printed by the Senate June 11, 1844. This report was also printed by order of the House, in 1845.

stones and soft sandstones are still lower in the bluffs, the river being on a sandstone. Another section extends from the Blue mounds to the Wisconsin river at Arena.

The greater part of Dr. Locke's time and energy were spent, during this survey, on magnetical and barometrical observations, this being more in keeping with the trend of his ambition and taste, as well as his instructions. He presents a "magnetical chart" showing the lines of equal dip, crossing the lead region. There was a curious notion prevalent, shared by Owen as well as Locke, that the dip compass might be affected by the ore bodies of the lead region, and Dr. Owen calls particular attention to the probable action of "protoxide of iron" on the needle. Locke, however, made a direct test as to the lead ore at Dubuque and found that the metallic vein exerted no peculiar magnetical influence.

In 1847 Dr. Locke was again called to the examination of United States mineral lands. He received the appointment of first assistant, with instructions, in the early part of the season of 1847, from Prof. C. T. Jackson, who had charge of the survey of the mineral lands in the northern part of Michigan. His field was from the mouth of the Chocolate river, where it joins lake Superior, to the little Bay de Noquet. This enterprise, however, so far as Dr. Jackson's plans were concerned, resulted in failure. Personal ambition and jealousy united with political intrigue and partizan greed and effected the removal of Dr. Jackson, and the final completion of the survey by other hands. According to Dr. Jackson's statement in his final report,* he learned from the commissioner of the general land office that the "appropriation for the survey was endangered by certain representations which had been made to a member of Congress by persons opposed to it, or by persons who wished to supersede me, by limiting the appointment to a citizen of Michigan." He does not mention any individual by name, but it may be inferred from events which followed, connected with those which are patent in the report of Dr. Jackson, that the same gentleman who subsequently broke up the Michigan survey under Dr. A. Winchell, had no little influence in effecting this revolution. Dr. Locke's report for 1847, so far as it appears in the printed report of Dr. Jackson, con-

*Journal of the Geological Survey for 1848.

sists of magnetical and barometrical observations, a catalogue of specimens collected, and daily journal from July 8, 1847, to August 30, the last mentioned evidently kept by some member of his party. It appears from this journal that Dr. Locke, after making a reconnoissance southward from lake Superior to the waters of the Escanaba river which enters little Bay de Noquet, returned to lake Superior, and thence, on his way to lake Michigan to make connection by way of little Bay de Noquet, made a detour into Canada, visiting the region of Bruce mines and Echo lake, and subsequently noted the geology of the shores of Drummond's island. Of the geology of this season's work, on which he was engaged in making a full report, with maps, Jan. 23, 1848,* date of his letter transmitting his magnetical observations, there is no report in Jackson's final report. Of this Dr. Jackson says:

I have sent Dr. John Locke's report on magnetic observations, and have requested him to send in some additional matter on the subject, and also his notes or report on the geology of the district which I assigned to him in 1847. His occupations in another service of the country during the past year have prevented his completing his geological report in season to forward to me, but I trust it will be communicated to you in season to be printed in my report.

In 1848 Dr. Locke

"was detached, by orders of the Secretary of the Treasury, as a magnetic surveyor, in accordance with my request, and a vacancy thus made in the assistants' corps was filled by my promotion of Mr. J. W. Foster to the place of assistant geologist." (p. 379.)

Dr. Jackson also says (p. 424):

"Dr. John Locke has been detached at his own request, and by the advice of the honorable Secretary of the Treasury, to make magnetic observations on both Dr. Owen's district and mine; but owing to the lateness of the passage of the appropriation bill, did not enter upon field duties this year. The appropriation bill not passing till August, it was considered then to be too late for the beginning of Dr. Locke's field duties, and the means placed at the disposal of Dr. Owen and myself were not sufficient to maintain that survey until the appropriation should be placed at our disposal. This was a matter of regret, for the magnetic observations had already begun to yield interesting results."

Dr. Locke does not seem to have returned to the survey under Dr. Owen, nor indeed to have been again actively engaged in the geology of the Northwest. He was doubtless deeply involved in his magnetic studies, to which Dr. Jackson

*Jackson's report, p. 556.

seems to refer in his own report as "another service to the country." His synoptical report for 1847, dated October 25, and printed in the Senate documents (II) 30th Congress, 1847-48, as a part of the report of the commissioner of the general land office, was sent in response to an earlier request of Dr. Jackson. It illustrates the negligence which pervaded the superintendence of the public printing at that date. It was so badly printed that, according to Col. Charles Whittlesey, Dr. Locke repudiated it entirely.* Following is an example of the proof-reading which it exhibits. It purports to be a list of the "Crustaceous" collected by Dr. Locke:

Calemens (probably the senaria ofceraurus pleut couried) rex anthems. Green.
Isoletus gigers.
Isoletus mesistus (mihi).
Asaphus—a large species.

The report confirms the prevalence of the idea that both the iron and all the other ores of the region were in some way dependent on magnetic currents and could be discovered by the use of the dip needle. He refers to a general statement made by him,† that his experiments go to show that the general nature of the subjacent rocks may be ascertained by the magnetic elements, the instrument serving the purpose of a divining rod. This idea he considered that his summer's observations did not contravene, but he also had discovered that there are greater deflections or local attractions in the northern part of Michigan than in other parts of the country. He projected a general magnetical chart of the United States, a kind of *Physical Atlas*. He calls attention to the incompatibility of magnetical and geological observations when conducted simultaneously, the former requiring more rapid travel and less exposure to delicate instruments. He suggests, what ultimately occurred, that the iron ore of the Negaunee region would be profitably brought to the limestone region of Bay de Noquet for smelting. He did not reach the mouth of the "Escanawby," owing to his insufficient force for "packing" the necessary provisions. John Locke, his nephew, was with him. His description of "pictured rocks" is interesting, as follows:

*Magazine of Western History, 1885.

†Trans. Am. Phil. Soc., April 19, 1844.

PICTURED ROCKS.

I had passed and repassed the "grand portal" of the pictured rocks three different times and had once made a sketch of it, but it seems I had never ascertained the extent of its interest. In passing it lately, all the circumstances being favorable, we determined to enter the arch with our boat, and though our mast was only about 16 to 18 feet high, still the feeling, as we approached, was that we must take it down to be able to pass under the apex of the arch: but drawing nearer the mast seemed to shrink and the arch to tower upward until our sail shook under a vault of 120 feet high. So much is the eye deceived by a general proportionate grandeur. Entering, we found ample room for a vast ship of war, with sails all standing, to conceal herself, turn round and come out without impediment. Although the water is deep for three-fourths of the way, yet, at the far end of the cave there is, first, a pile of huge fallen blocks of sandstone, and beyond these a sand beach 50 to 60 feet wide. Excited by a work so magnificent, I determined to make it my observatory until I had ascertained its form and dimensions as accurately as expedition would permit. For this purpose, and to enjoy a romantic luxury, I resolved on spending a night where I need not call on the mountains to hide me.

As there was a spice of danger in spending the night in this palace of winds and waves, I landed the party to encamp on the sands near the Doric rock, and was then transported and left in the cave, with my nephew and instruments, the voyagers returning with the boat to the encampment. Here we were more securely imprisoned than Napoleon on St. Helena, the only means of escape being to climb over hanging rocks 200 feet high, or swim half of a mile of the lake, with water so cold as to stiffen us in one-eighth of that distance, and our provisions, a few sticks of wood, which we brought in the boat, and a bucket of bean soup. But we gave ourselves no anxiety, for we had too much work to perform. Immediately we measured our base line, for triangulation, 500 feet long, all within the cave of the great arch!

At this part of the pictured rocks there is a table of sandstone about 200 feet high, presenting to the lake a perpendicular wall of waving and angular outline for several miles. At the grand portal the rock juts out into a short peninsula by two curves, which come up like the curves from the shoulders in each side of the neck. At the end it is abruptly truncated, as if the head had been cut off. Into this truncated end enters the grand portal arch, about 120 feet high, and, penetrating about 300 feet, terminates in two smaller arches. Near the far end, a cross arch, opening on each side of the neck, traverses the main cavern. Thus the ground plan, like that of ancient cathedrals, is a cross. In the portal, however, the head of the cross is double. We ventured to give names to the various apartments. 1st. The grand dome, opening in the grand portal. 2d and 3d. The first and second dormitories. 4th. The left wing of the cross. 5th. The right wing of the cross. 6th. The vestry, with columns, groined arches and Gothic windows, communicating with the right wing. 7th. The Egyptian labyrinths, consisting of

cylindric and groined galleries, supported by peculiar columns, having a distinct resemblance to the Egyptian, communicating both with the right wing and with the grand dome. The form of the columns is that of two elongated bells, with the two small ends joined to form the middle of the shaft; or, to detail the figure, it is expanded at the top like an inverted bell, contracting rapidly as it descends, and, by a gradual curve, becomes nearly cylindric for some distance; and again it contracts, on a gradual curve, till it comes almost to a point, where it meets the same figure reversed. This form is essentially beautiful, being a solid, generated by rotation of Hogarth's sigmoid line of grace. To explain the mode of its formation would lead to too long a discussion.

Our most active and frolicsome half-breed voyager had waded the water and, without our perceiving him, had entered the labyrinth. To our surprise he thrust his head out of a hole in the wall of the grand dome and uttered a hideous growl. His companions instantly took up the drama of the beast in his den, and hurled a volley of stones at him. Darting back, Legarde presented his head at another opening and defied his pursuers with a still fiercer snarl. Instantly there followed another volley, another evasion, and another peal of laughter echoed back from the dome. I labored hard until dark, and then discovered a new danger in making it my place of rest. I found a great part of the interior of the cave to be lined with a shell of stone, loosened by last winter's frost, and ready, at all points, to fall with crushing force. Going back to the farthest recess of the dormitory arch, I knocked off all the loose stones, propped up my cot on piles of rocks and composed myself to sleep, not unmindful, as I laid down, that the canopy of my bed was of solid stone 200 feet thick, with a forest of fir trees on top as the ornamental fringe. About midnight I arose, lighted a candle, built a fire, and walked forward with my lantern to the farthest block of stone. Here I gazed at the great star-lighted window, presented by the portal arch; and, as I stood, the polar star just twinkled on the verge of the opening, making the angular altitude equal to the latitude of the place. Again I laid down in the dormitory and listened to the dirge-like music of the ripple as it kissed the rocky fragments and danced into the labyrinths. In such situations there is often a mirage of sound as wonderful as that of light. The discords seemed to be absorbed, and the harmonious notes are echoed and reverberated with more enchanting spells than belong to the æolian. Commingled with the dirge one imagines imitations of cascades, hail, rain and storms. This was pianissimo. The fortissimo would be witnessed when the northern storm should drive the thunder of the great lake into the grand portal. Suppose this was to have happened while I was a tenant, it was really what I desired. An avalanche of rock sufficient to have crushed a city had fallen just outside of the left arch and laid rudely piled to the hight of 50 feet. Thither I would have retreated to witness the bloodless battle of the elements; for a long war has been waged between waves and rocks, in which the rocks, so far, have been obliged to yield. Morning came, and,

with the dawn, myself and nephew were at our work of triangulating. Finally, having completed the survey and obtained geological specimens of great interest, we joined ourselves to the world again. I shall calculate my observations, make drawings of ground plan and elevations and include them in my report to Dr. Jackson, and, through him, to the government, that, if they are found worthy of it, they may be published. I need hardly say that such a curiosity, in such a climate, deserves a visit from the Cincinnatians during the hot months. Within half a mile is a boat harbor, a fine camping ground, and still another half mile along the beach is the Chappel rock, and still nearer a cascade. Beyond this again is a cascade, leaping from the top of the pictured rocks clear into the lake, and blowing a blast of wind in all directions from where it strikes the water sufficient to propel a sailboat.

The grand portal is less extensive than the mammoth cave, being a mere fraction of it: but it has several compensating beauties. It has a light and fine breeze, and it is, at the same time, as cool. You arrive at all of its beauties without fatigue, and enjoy, through its open arches, the most extraordinary landscapes. Through the grand portal you see only the shoreless lake. Through the western opening of the cross arch a limited but magnificent view of the lake, the pictured rocks overhanging its dark blue waters, on whose surface, when calm, those rocks are reflected into a symmetrical counterpart of the original. Through the eastern wing is seen also the lake and pictured rocks, dying away in well marked perspective, as one point sinks behind the other, to the distance of 10 miles. In the course of this perspective is the cascade of Chappel river, the Chappel rock and the cascade of the winds. This cross arch is 500 feet long and so straight that light is seen through it from one side to the other.

Mr. Schoolcraft passed through it with his boat, but the lake having fallen about four feet it is now barely dry, and the only entrance by water is by the grand portal.

Dr. Locke identified the Blue limestone on St. Joseph's island, and the Cliff on Drummond island. The latter he traced westwardly to great Bay de Noquet. From the dip and the succession of the various formations between St. Joseph's and Drummond islands he concluded the red sandstone at St. Mary's falls belongs beneath the Trenton and Cincinnati limestones, "and is therefore rather the older red sandstone than the new red sandstone." This was contrary to the opinion of both Jackson and Houghton. The limestone (the Trenton) which he found on the west side of little Bay de Noquet he rather thought belonged to the Carboniferous, and imagined a fault-plane running north and south under little Bay de Noquet in order to bring about such a position for a much younger limestone, as he knew of no such rock beneath the Blue lime-

stone at Cincinnati. With the exception of this error, he outlined the geology of the northern peninsula of Michigan eastward from Keweenaw bay. If his full report on this examination had been completed and published it certainly would have constituted an important chapter in the progressive development of the geology of that state.

This, apparently, was Dr. Locke's last geological work. The study of magnetism and the increasing exactions of his professorship at Cincinnati engrossed all his attention.

Personally, Dr. Locke was slightly above medium hight. From his feet to his eyes, as stated by himself in explaining the use of his "level," he measured 5 feet 5 inches. He was not physically rugged: his countenance had usually the sickly, almost sad, expression of a severe student. He was indifferent to exposure, either of cold or rain, and never carried an umbrella. When involved with some problem of physics it was his habit to give himself no rest. His nervous excitement sustained his physical powers with little aid from sleep. Prostration usually followed, but he was soon at his work again. This habit doubtless permanently injured him both mentally and physically, for his death at 64 years was described as due to "a breaking up, as it were, of the great nervous centers." In manner he was marked by the dignity of his address and the courtliness which partook of the old regime of the eighteenth century. He was a man of fine presence, with an open and benignant countenance, in all respects a rare specimen of cultured manhood. In Ohio his home was for some time at Lebanon, the home of Tom Corwin, and they became firm friends. Locke, Corwin and Thomas Ewing, the last the father of Mrs. Gen. W. T. Sherman, were very close friends, making a notable trio. It was at Corwin's instance that Congress purchased Dr. Locke's electro-chronograph.

Dr. Locke married Mary Morris, of Newark, N. J., in 1825. She had been one of his pupils. She was a most estimable lady and his domestic life was a very happy one. They reared a large and interesting family, but one son died young and two in early manhood.

Dr. Locke's career, from first to last, was a remarkable one. Single handed, as a youth, he attacked the outworks of a great problem the issue of which was, to say the least, precarious—

to win a recognition among educators and scientists. He made rapid progress toward the front. His inventions were numerous and his publications were of the highest value both in physics and geology. For seventeen years he held an important professorship in one of the leading institutions in the central portion of the United States, and at his death it was truly said that the country had lost one of its foremost citizens.

The following list of Dr. Locke's publications is probably complete for his geological contributions. There is mention made, amongst the memorabilia sent by Mr. J. B. Locke, of an English grammar, and a "pamphlet on Toxicology," but of these no further information can be obtained.

LIST OF THE PUBLICATIONS OF DR. JOHN LOCKE.

Outlines of Botany. 1819.

The microscopic compass: invented by John Locke. Am. Jour. Sci., Vol. XXIII, 1833, pp. 237-243.

On a large and very sensitive thermoscopic galvanometer. Phil. Mag., London, 1837. [Reprinted in Am. Jour. Sci., XXXII, pp. 365-368, 1838.]

Magnetical observations at Dayton, Springfield, Urbana and Columbus, Ohio. Jour. Franklin Institute, Oct. 1838.

Geological report communicated by the governor to the General Assembly of Ohio. Dec., 1838. Addressed to Prof. W. W. Mather, principal geologist of the survey, 66 pp. octavo, 15 plates and a colored geological map of Adams county. Published in the second report of the first survey.

Report on the explosion of the steamboat Moseler, 1840.

Electricity in steam. Contributed to the National Institution for the Promotion of Science, Jan. 22, 1841. [Apparently not published.]

On a new species of trilobite of very large size. Am. Jour. Sci., 1842, XLII, p. 366.

Alabaster in Mammoth cave, Kentucky [Illustrated]. Am. Jour. Sci., XLII, p. 206. 1842.

On the manipulations of the dipping compass. Am. Jour. Sci., XLII, 235, 1842.

On the geology of the upper Mississippi. Am. Jour. Sci., XLIII, 147, 1842.

A new species of trilobite of very large size. Report of the 1st, 2d, and 3d meetings of the Assoc. Am. Geol. and Nat. [1843], pp. 221-224.

[NOTE.—This trilobite is the same as described in the Ohio report for 1838, and in the Am. Jour. Sci., 1842, but the name is here changed to *Isotelus megiston.*]

Ancient Earthworks of Ohio. Rep. 1st, 2d, and 3d meetings, Assoc. Am. Geol. and Nat. [1843], pp. 229-238.

A new reflecting level and goniometer. Rep. 1st, 2d and 3d meetings, Assoc. Am. Geol. and Nat., p. 238 [1843].

Notice of a prostrate forest under the diluvium of Ohio. Rep. 1st, 2d, and 3d meetings, Assoc. Am. Geol. and Nat. [1843], pp. 240-41.

Observations on Cryptolithus tesselatus. Proc. Phil. Acad. Sci., 1843, pp. 196-236.

Description of Ceraurus crosotus. Am. Jour. Sci., XLIV, 1843, p. 346.

Supplementary notice of Ceraurus crosotus. Am. Jour. Sci., 1843. Vol. XLV, p. 223.

Casts of American fossils presented to the Phil. Acad. Nat. Sci. Vol. I, 1843, p. 174.

Sulphate of lime or fibrous gypsum from Mammoth cave, Ky. Phil. Acad. Nat. Sci., Vol. I, p. 244, 1843. [For this the name oulophyllites is suggested.]

Report of John Locke, M. D., to David Dale Owen, M. D., principal agent to explore the mineral lands of the United States. Embraced in Dr. Owen's report of work done in 1839, in Iowa, Wisconsin and Illinois. Senate Ex. Docs., No. 407, 28th Congress, 1st Sess., 1844. [This report was first printed as a part of a special message from the president (dated June 4, 1840) in 1840, without the accompanying charts, sections, and other illustrations. Besides the edition ordered in 1844 by the Senate, 1,500 copies, the House ordered for its own use, an edition of 5,000 copies, Feb. 25, 1845.]

Observations made in the years 1838, '39, '40, '41, '42, and '43, to determine the magnetical dip and the intensity of magnetical force in several parts of the United States. Trans. Am. Phil. Soc., Vol. IX, 283-315, April 15, 1844.

Geology of Porter's island and Copper Harbor [Isle Royale]. Trans. Am. Phil. Soc., IX, 311, 312 (pp, 305-315), with maps, 1844.

Geology and Magnetism. Trans. Am. Phil. Soc., April 19, 1844.

Observations on Terrestrial Magnetism. Smithsonian Contributions, III, Art I, pp. 1-29, 1851.

——————. Trans. Am. Phil. Soc., 1846, p. 242.

Description of Asterias antiquata, from the Blue limestone of Ohio Proc. Phil. Acad. Sci., Vol. III, pp. 32-34 (with figure), 1846.

[NOTE.—In this Locke corrects the idea maintained by Troost and Featherstonhaugh that this is the Carboniferous limestone.]

Synoptical report on the geology of the northern peninsula of Michigan, addressed to Dr. C. T. Jackson, Oct. 25, 1847. Senate documents, 1847, 1st Sess., 30th Congress, comprising pp. 183-199 of the report of the Commissioner of the General Land Office.

Catalogue of specimens forwarded to Dr. Jackson by John Locke, Dec., 1847. In Dr. Jackson's report for 1848, pp. 547-556.

U. S. Geological survey of public lands in Michigan—Field-notes. [Evidently these notes were taken by some member of Dr. Locke's party in 1847.] Dr. Jackson's report for 1848, pp. 556-570.

Report of Magnetic observations by Dr. John Locke, assistant geologist. In Jackson's report for 1848, pp. 572-589.

Report on the invention and construction of the electro-chronograph clock at the National Observatory, Washington. 1851.

Catalogue of rocks, minerals, ores, and fossils collected by John Locke during 1847. Smithsonian Report, 1854, pp. 367-383.

The devotee of Science and the National Institute. [Quoted by Dr. M. B. Wright in his memorial address, p. 42, 1857.]

THE "SLATE BINDERS"* OF THE "PITTSBURG" COAL-BED.

By W. S. GRESLEY, F. G. S., Erie, Pa.

Given, a "bench" or layer of good bituminous coal, of very uniform quality, varying in thickness from say 22 to 27 inches, with one or two more or less irregular slaty partings or binders here and there in it; and imagine such a deposit spread out over at least 15,000 square miles. The edges or outcroppings of this layer of coal reveal no signs of a beginning or of an end; in other words, there is nothing to indicate that this coal did not originally extend hundreds of miles beyond any of its existing limits. We will not now discuss the question. How did this layer of coal get where it is? but proceed at once to observe that it has a practically dead-level and even surface or top.† Suppose this vast expanse of dead-level coal vegetation to be completely covered or sealed over by a thin layer or band of shale, or "slate," as miners call it. We will suppose the thickness of this film of shale to be from ¼ to ½ of an inch only. Imagine a practically unbroken 15,000+ square mile sheet of shale only ⅜ of an inch thick! On top of this shale-band let a second and equally uniform layer of the same coal as the thicker one below, be deposited, whose thickness is about 4 inches—a layer of coal practically free from impurities, and, in every respect, similar to the rest of the seam, regarded as a whole. Again, on top of this 4-inch band of coal conceive a second layer of shale to exist, in thickness and kind just about the same as the shale-layer 4 inches below it. Then above this suppose we have a uniform bench of coal 3 feet to

---

*Binders, in coal, are thin interstratified layers of shale, more or less mixed with pyrites, etc.

†The only breaks or interruptions of the continuity of the seam being a few small and local banks or ridges of rock, called "horse-backs," rising from the floor.

5 feet high. Here, then, we have three separate and distinct benches or divisions of a coal-seam separated horizontally by a couple of thin, parallel-bedded layers of shale; or, looked at in another way, we have a, say, 15,000 square mile 4-inch band of excellent coal sandwiched between two very thin, but remarkably persistent layers of what is presumably hardened mud, these again being enclosed by thicker layers of the same kind of coal. Now, the foregoing is in reality a description of what actually occurs in nature; it is the lower or workable division of the "great Pittsburg bed." These two "slate-binders" seem to be so remarkable as regards their geographical extent, uniformity in thickness, composition, distance apart vertically, etc., that some special effort ought to be made to explain: 1—What they are or signify; 2—How they got there; and, 3—Whence they came,—three questions, so far as I know, not yet at all satisfactorily answered, and much less easy of solution than at first sight appears. My wish in this connection is that this paper may stir up sufficient interest in this matter to lead to further, extended, and closer observation; and such a detailed study of the Pittsburg bed as it (a typical one) surely deserves and ought to receive at the hands of all local geologists and men capable of doing useful work on it. Of course, the question of the origin and formation of the shale-bands in the coal opens up that of the whole question of the formation of coal-seams, for the bands are part and parcel of the seam; the two substances (coal and shale) cannot be considered separately.

Most geologists have access to about all that has been published in the way of detailed sections, etc., of the Pittsburg bed, and so are more or less familiar with its geographical extent as shown upon geological maps; so that to copy a host of sections and cite others would be superfluous here. We all know by this time how vastly greater in areal dimensions this seam of coal must originally have been, compared with what it is now. Prof. Lesley sees no reason why it may not have extended north far into what is now Canada, and north-east at least as far as the hard coal region of Pennsylvania. That it is a typical coal-seam nobody disputes; that the coal is the remains of Carboniferous-period vegetation no geologist denies; but *how it got there*, nobody knows, although

some seem to think they know. In order to reach a reasonable explanation of the origin and formation of the shale partings we should, if possible, be able to answer the questions: where did the coal vegetation all grow or come from? and how was it put in place? But whether it grew on or about the spot where its remains now are, or was transported or sorted by water in one of the several ways geologists have supposed (myself among them), we may, I think, take it for granted that the lower of these two shale-layers got there during a pause,—a temporary stoppage of the growth or accumulation of vegetable matter within the region affected by the slate-parting. However this may have been, we will proceed to look closely at the "slate" itself. As the appearance of the two slate-bands is identical it matters not to which the following description be applied:

Description of the shale forming parallel bands in the Pittsburg coal.

Macroscopic. Very fine-grained, in fact granules of ground mass not distinguishable. Specks and streaks of coal. Often a brecciated appearance, due to mottling. Should suppose the sediments had been derived from clay-slate or still older muds.

Texture. Homogeneous, compact.

Fracture. Irregular, splits roughly parallel with bedding planes. Almost free from joints.

Streak. Pale, brownish gray.

Luster. Earthy, dull.

Taste. Sometimes salt or astringent (? alunogen).

Color. At a distance, dark, brownish black or gray; close to, variegated or mottled by numerous shades of gray, brown, etc., of which more further on.

Sp. gr. Probably about 2.60.

Non-plastic.

Fossils. Flat, long leaf or reed-like, compressed forms of an obscure nature; many *macrospores*. Impressions on surfaces of *Sigillaria*, etc. [*Stigmaria* never recorded in this seam.]

The shale sometimes parts easily from the coal next it, but in other places the planes of demarkation are less pronounced. So far as my observations go, the shale bands only show abnormal thickening in proximity to or in contact with faults or comparatively recent disturbances of the coal bed, where the cause is easily explained. The "cleat" in the band of coal between the two thin slates is the same as that of the lower and higher benches of the seam, viz., strikingly uniform.

As to the mottling. I can best describe this by saying the rock is rudely but obscurely brecciated or fragmental-looking, often grading into a marbly or streaky vein-like, vitreous aspect, as though a variety of fragments of shale, etc., of different tints had been in a semi-liquid or run-together state, producing a slaggy or drawn-together, kneaded aspect. Some parts of the rock are much darker than others. There seems to be considerable differentiation in coloring and in shapes and sizes of the blotches; the individual blotches are even variegated, spotted, streaked, etc. In general, the appearance, as revealed by a pocket lens, when the rock is wet, and in a strong light, reminds one somewhat of the structure of ordinary serpentine. Pyrites occur in tiny nests or aggregates of crystals scattered through the groundmass.

A polished surface of a fragment viewed at right angles to the bedding planes shows the character of the mottling or marbling shown in fig. 1.

FIG. 1.

FIG. 2.

Viewed in the direction of the stratum, i. e. a transverse section appears as in fig. 2. Thus it will be seen that the blotches are several times longer in the horizontal direction than they are vertically.

The fossils do not seem to pay any attention to the variegation, nor does the texture of the rock vary with the blotchings. It would appear therefore that the mottling is the result of chemical action among the particles produced since or during consolidation of the deposit; though one occasionally finds a specimen imitating variegated breccia to a degree which even suggests uncertainty about the mottling after all. That the particles composing the shale were largely derived from feldspars is tolerably certain; and the mottling process may even be still going on. Of course the layers of shale originally possessed horizontal limits, and, if they be regarded as

layers of sediment transported and stratified by or under water, the original shape was probably more or less lenticular, being thicker and coarser shoreward, and thinner and finer-grained seaward. And since, in the area in which these binders are now confined, their composition, texture, etc., hardly seem to vary at all, we naturally ask, How large an area did the now denuded, binder-divided coal seam once upon a time cover?; the only answer is, simply immense! Can we suppose anything short of scores of times larger than at the present day!

What do the facts seem to suggest?

(a) Having to deal with a comparatively very thin sheet of what looks like an originally almost impalpable powder or the finest slime or mud, distributed in a marvelously uniform manner, and covering an area almost continental in size, we wonder which of the known ways in which strata are formed best answers or explains the phenomena. Basing our argument upon the supposition that the termination of the deposition of the stratum of coal-forming vegetation upon which the lower sheet of shale rests, found that stratum lying practically level as accumulated under water or on the bottom of a vast lake or inland sea, let us endeavor to imagine the waters to be charged with fine particles of sediment, brought in from the mouth or mouths of immense rivers flowing in the then continental areas which furnished the sediments composing the coal-measures. The character of the shale binder points to a uniform mixture of sizes and kinds of particles, to an even or continuous supply of the same at the commencement of its falling to the bottom of the water, during all the period thus occupied in sedimentation, and up to the time the particles ceased to accumulate; practically no variation in strength or velocity of current of water supplying or parting with its muddy ingredients; a rate of flow of water hardly perceptible; a period of calm as regards wind and waves; a depth of water absolutely the same all over the expanse or area of precipitation; this implies perfect freedom from local currents and irregularities of bottom; no drifting logs or snags to scrape or plow up the bottom; a time on land of no floods or droughts important enough to interfere with or break the continuity of the supply of mud transported. We have also to suppose that the rivers, deriving sediment by

erosive processes on land, flowed over or through rocks of marvelous uniformity, otherwise how could the finest sediments derived therefrom preserve their sameness?; also that no changes or disturbances took place from an off-shore or in a landward direction meeting the waters from the rivers; a contemporaneous set of physical conditions, in short, are apparently demanded for the accumulation of this film or layer of mud, which is indeed hard to conceive. We ask, Can such a period be reasonably supposed to have actually happened? It must be borne in mind that it would take about 100 tons of sediment to cover each acre about $\frac{1}{2}$ inch deep; also that a 15,000 sq. mile sheet of shale $\frac{1}{2}$ inch thick is in the same proportion as one sq. mile covered by a film $\frac{1}{30000}$ inch thick. Will or can transportation of sediment by water produce such wonderful uniformity of deposition or precipitation on the bottom as the application of the method calls for?

(b) Take the eolian process. It seems to me that the observed facts in regard to these binders would entirely forbid the acceptance of the idea that this shaly material got there by the agency of wind, i. e. that it was dust blown or carried off the land and dropped in an even manner upon the quiet waters of a great inland sea.

(c) Concretionary. If these parallel bands of shale had had a concretionary origin, they must have taken another form. Concretions are characterized by their irregular or nodular shapes, by a tendency to spherical or ringed structures, to differences in texture, hardness, fracture, etc., so that while the mottling may in part be due to some slight action of the kind within the layers, the origin and formation of the layers themselves cannot be attributed to concretion.

(d) Substitution or replacement formations. This implies that the binders were originally part and parcel of the coal-bed, regarded as a whole, and that during solidification or the process of coal-forming most of the carbon and of the volatile matters made way for concentration (along definite horizons in the bed) of the inorganic matters in the vegetable mass; that in fact there was set up, at different hights in the coal-mass, molecular affinity, perhaps akin to the process of segregation or leaching, among the particles, resulting ultimately in the growth of definite sheets or bands to the nearly total

exclusion of coaly substances. Since replacements or concentrates are almost entirely confined to calcareous and siliceous rocks and those readily acted upon by metallic solutions, and seldom take a regular horizontal or definite and stable form, I, for one, would not accept such an explanation of these coal-seam shales. To suppose that such shale-bands were originally thin films of chalky mud, since chemically converted into silica, alumina, iron, etc., etc., would, I think, be exceedingly unsafe; and yet the formation of widespread layers of something similar to chalk in composition at the present day (the "Globigerina ooze") over the bottom of the Atlantic ocean where deepest and farthest from land, would seem to furnish us with about the only way (as to physical conditions) in which our shale-binders in the "Pittsburg" coal-bed can be imagined to have accumulated.

(e) Precipitates. There occurs to me only one other known process or way by which these binders could come into the coal; it is on the supposition that the waters overlying the coal layers were so highly charged with minerals in solution that in the end there came a time when these were precipitated as solid particles. Hence a sheet of uniformly-composed mineral ingredients was brought into existence and solidified where it lay. This theory makes these binders chemically-formed rocks. But, in my opinion, such an explanation of them will be rejected.

Now, if the lower of these two slate-binders was really deposited as a layer of fine silt or mud by the aqueous transportation process, it becomes interesting to enquire: How was the succeeding or superimposed four-inch band of pure coal created or put there? for, in reality, *it* is a bed of coal *per se*; and they who would regard coal-beds as remains of trees, etc., that grew where or near where the coal now is, with underclays for their roots to meander and develop in, will have to consider this ¼ to ½ inch layer of shale as the *underbed* of the four-inch layer of coal. I merely make this observation here to show how exceedingly cautious geologists should be when attempting to handle the subject of the origin of coal seams.

Geological text-books don't seem to help us one bit in trying to find a satisfactory explanation for the formation of anything so extensive, geographically, as these particular ½

inch layers of slate in the pure coal. The Mississippi river is said to deposit an amount of detritus in one year found to be approximately equal to one of these thin binders, but then we are told most of this river material goes toward the augmentation or extension of the river's delta. But our coal shale-binders, as already pointed out, contain no signs of a typical delta formation. Flocculated particles are common to fine river deposits. In these shales flocculation is not observed.

Again, it is only reasonable to suppose that either of these shale-layers, whenever and however formed, was accumulated at one time, whether it took one year or ten years to do it; the process was uninterrupted, it operated uniformly both laterally and vertically.

The "Pittsburg bed" contains several other binders or "dividing slates" besides the twins under consideration, but these are all of less persistent character and variable dimensions; they, however (so far as my examination has gone), are all practically identical in composition and texture.*, though the degree of mottling may change locally; thus everything points to a common origin and source of the materials of all the binders by which this splendid and unique coal-bed is horizontally and stratigraphically divided, also a very similar mode of deposition or formation for one and all, whatever it was. Although apparently, perhaps, a not difficult coal-bed to explain geologically, a more close study of its stratiform composition extending over wide areas brings it, to my mind, well within the category of geological problems by no means as yet satisfactorily solved.

The thickening of the "Pittsburg bed" is in a southeasterly direction, so also is that of the "bearing in" and other slates. Thus the evidence goes to favor the assumption that both the organic material (the coal) as well as the inorganic (the "slates") had their source or chiefly depended upon or were largely governed by the land surface towards where the Atlantic ocean is now.

Whenever the geologic history of *this* vast coal seam shall be something like correctly made out or described, there will be

*Except the bed of impure fire-clay or "draw-slate" of the miners, which lies immediately on top of the 3-5 feet bench of coal already referred to.

little or no difficulty in accounting for most of the things that now puzzle us in connection with *other* seams; but I am rather afraid, unless a larger number of competent observers take up the working out of the geology of the "Pittsburg bed" than seem to be now so engaged, the seam itself will be about all "worked out" ere the problems which confront us are settled.

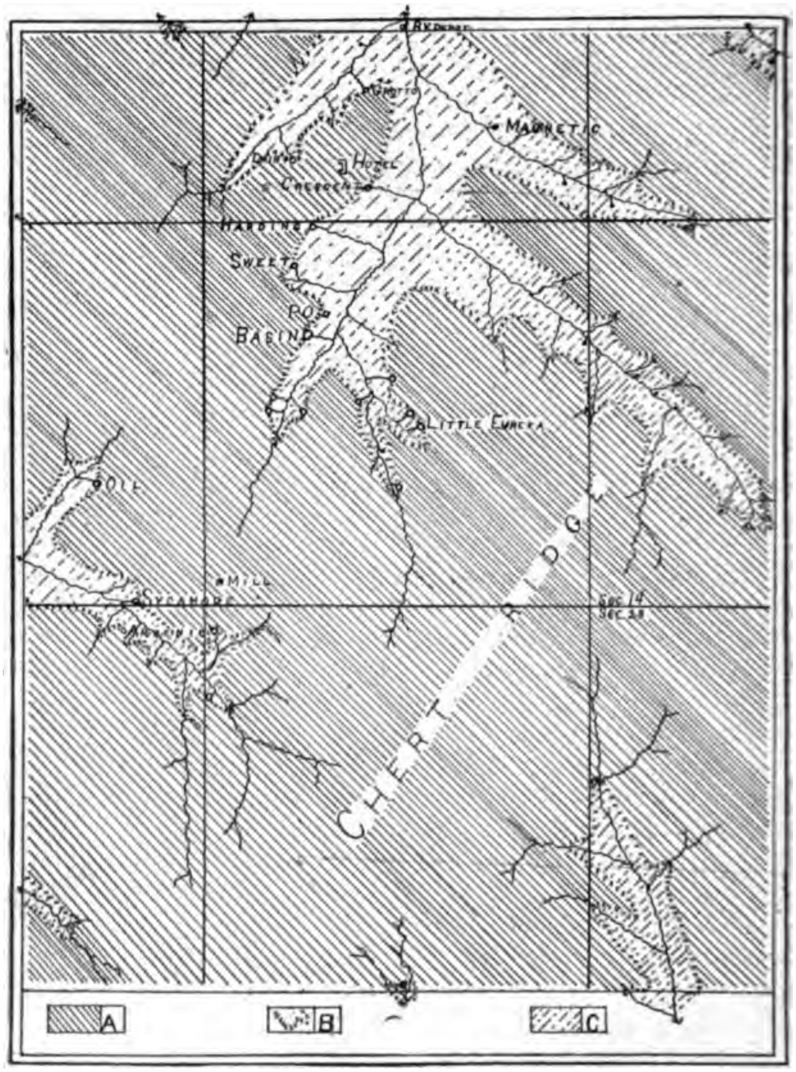
Anent this coal seam question it should not be forgotten that, as yet, the form *Stigmaria* (in any of its various phases) has not yet been reported in connection with it.* This circumstance alone casts reasonable doubt as to its growth *in situ*, origin, or formation, as usually understood. Moreover, I find its floor or under bed (that of the 22-27 inch bench of coal forming the basal member or division of the seam) to be a calcareous shale, wherever I have examined it, carrying very numerous remains of an aquatic fauna.

The extraordinary uniformity of the Pittsburg bed as to purity and structure of coal, evenness and geographical extent of its various strata, its widespread interstratified shales and the marvelous persistency of them, and other characteristics, make this seam, in its entirety, the most remarkable, most typical, most interesting one of which we possess any knowledge; it is probably the most extensive instance of horizontality or parallelism in stratification any geologist in any country ever did or ever can point to. It is certainly phenomenal; and yet I maintain that a rational explanation of any of its individual layers, from and including underbed to topmost member, has yet to be found. About all that can with safety be said about it is that, everything being horizontally stratified, every part of it was most likely accumulated under water. I have therefore come to the conclusion that this coal bed is the accumulated remains on the bottom of a lake or sea of vegetable growth of *aquatic forms*† (though much of it did not necessarily grow *in* the water) living afloat and dying and decaying, falling through the water.‡ I do not recollect

*The only fragment at all resembling *Stigmaria* I have seen or heard of from the Pittsburg horizon was one found by myself near Elizabeth, Pa., on a bit of a shale binder in 1892.

†Vegetation of such character as thrived in luxuriant profusion upon the surface of the water.

‡See Quart. Journ. Geol. Soc. of London for August, 1894.



MAP OF EUREKA SPRINGS AND VICINITY, ARKANSAS.

Showing the influence of stratigraphy on the emergence of springs. A, Lower Carboniferous chert; B, Shale and sandstone horizon for springs. C, Silurian limestone, chert, etc. Scale, 2 inches to a mile.

having observed anything in this coal bed or in the strata immediately below and above it that could be regarded as evidence against the idea just stated. The absence of *Stigmariæ*, of erect tree stumps with root processes attached, and of irregularities of stratification; and the presence of numerous remains of a rich aquatic fauna in places and at more than one horizon in the seam;* with, here and there, areas of limestone where the "draw-slate" occurs (in which "slate" I have seen a traveled boulder of hard yellow limestone)—all these facts can only be explained by an aqueous origin for this coal.

SPRINGS: THE INFLUENCE OF STRATIGRAPHY ON THEIR EMERGENCE, AS ILLUSTRATED IN THE OZARK UPLIFT.

By T. C. Hopkins, University of Chicago, Ill.

(Plate XI.)

There is probably nowhere in the United States a better opportunity for observing the influence of stratigraphy on the emergence of springs than in the Paleozoic area of northern Arkansas and southwestern Missouri, an area known as the Ozark uplift.

In most mountainous areas the strata are generally much flexed and faulted, so that the emergence of springs is governed largely by the position of the strata and is not so directly dependent upon the lithologic character of the different layers as is the case when the strata are horizontal or nearly so, with only few faults. Over a large part of the Ozark uplift the strata are very nearly horizontal and are deeply eroded by White river and its numerous ramifying tributaries, thus exposing a great vertical thickness of the different layers, so that we have a nearly ideal condition for observing the direct influence of the different beds on the emergence of the springs. It is true that the Grand Canyon area of the west has deeper erosion, but the lack of rain makes it springless.

The strata in the Arkansas-Missouri area consist of differ-

*See Pa. Geol. Surv. Final Report, vol. iii (to be published, 1894).

ent beds of sandstone, limestone, shale and chert, a general section of which is given in the following table:

General section of the Paleozoic strata in northern Arkansas.

		Feet.
1.	Millstone grit, coarse sandstone	400
2.	Black shale and shelly limestone	50 to 250
3.	Archimedes limestone, partly crystalline	50 to 80
4.	Shaly sandstone	20 to 200
5.	Black argillaceous shale	100 to 250
6.	Yellow ferruginous sandstone	50 to 170
7.	Black argillo-calcareous shale	30 to 300
8.	Chert and limestone	370
9.	Sandstone, coarse, rounded grains	40
10.	Black argillaceous shale	2 to 50
11.	Crystalline limestone	100 to 155
12.	Compact blue limestone	280
13.	Saccharoidal, white, friable sandstone	5 to 150
14.	Magnesian limestones, chert, and sandstone	1,600

Not all of the above are exposed on any one slope. Probably in no case is the immediate slope more than 2,000 feet above the stream, the average hillsides being 500 to 1,000 feet. Yet over the entire area each formation is exposed in many places, generally four or five or more on each slope.

Not all of the above beds extend over the whole area. Numbers 1, 6, 8, 13 and 14 are persistent, occurring at all points in the area where the proper horizon is exposed. Numbers 9 and 10 are very irregular, rarely both being present at the same time, and frequently both being absent, or if present only an inch or two in thickness. Numbers 11 and 12 are persistent beds over the eastern half of the area, but are wholly absent from the western half, so that at many places in the western part of the area No. 8 rests directly on No. 10, where it is present, and on No. 13 in the absence of No. 10. The significance of this will appear in what follows.

Springs are abundant all over the area, some noted for medicinal properties and all remarkable for the clearness, purity and volume of the water. One, the Mammoth spring, forms a river in itself; and from many others flow large-sized creeks.

While springs occur in almost all of the above formations, by far the greater number, possibly more than half, the springs of the whole area emerge on No. 10 or No. 13 of the accompanying section. The cause for the emergence on No. 10 is very plain, as it is a compact argillaceous shale; but it

is not so clear why No. 13 should have so great an influence, as it is a very friable white sandstone, composed of almost pure silica. It is so friable in places that it can easily be rubbed, in the hands, into a loose mass of white sand resembling granulated sugar. The state geologist has suggested capillarity as an explanation of its impermeability. I think, however, that two other factors play a very important part: first, the indurated surface, since in nearly all places a thin hard crust has formed over the surface, by the deposition of silica, iron and possibly lime; second, the shale may be more abundant than would appear from surface exposures. Thus where the outcrops on the hillsides would indicate only traces, or the absence, of the shale, it may underlie a larger part, possibly the greater part, of the hill; its absence on the surface being due to local thinning of the bed, a characteristic of this formation, or to the weathering away of the shale near the surface, permitting the overlying limestone and chert to settle down on the underlying sandstone. This last factor is applicable only to the western part of the area, where the limestones, Nos. 11 and 12, are absent.

In the eastern half of the area the shale is more variable in thickness than in the western half. Where it has a thickness of two or three feet or more, it is a prominent horizon for springs. Where it is absent or very thin, the springs are absent and the top of the sandstone No. 13 is the prominent spring horizon.

The explanation for the excess of springs emerging on Nos. 10 and 13, over the number emerging on the almost equally impervious shales of Nos. 2 and 7, is found in the character and distribution of the chert and limestone bed No. 8. In this bed the chert predominates in most places; and in all places it predominates on the surface, owing to its greater durability. It is very much jointed, and the weathering opens these joints, strewing the surface with a mass of loose angular fragments. The rain and snow water sink so quickly into this mass of broken stone that very little runs off as surface water. This chert covers a much larger surface area than any of the other beds, probably due in part to old baseleveling, and in part to its greater durability. It covers a large area

with a great porous mantle, which readily admits the surface waters that trickle down through it until they meet the less pervious bed of shale, No. 10, or the sandstone, No. 13.

The accompanying plate XI represents a typical area in the western half of the district. It is a map of Eureka Springs and vicinity, drawn to scale from a survey of the area. It shows nearly all the constant springs, but omits many smaller ones that flow only during a part of the year. The shaded area on the map represents the cherty limestone of No. 8, which forms the tops of all the hills; the broken line is the outcrop of a bed of crystalline limestone ("St. Joe marble") forming the base of the chert bed. The black shale No. 10 is present here in places as a bed varying from two to five feet in thickness and many of the springs emerge on it. Where it is absent or thin the springs emerge on the sandstone No. 13, which immediately underlies No. 10. The unshaded part, marked as Silurian, includes the sandstone No. 13 and several beds of No. 14.

As may be seen, of the thirty-eight springs on this area of five square miles, twenty-six emerge at the base of the chert bed, and only twelve find their way through the shale and sandstone into the underlying magnesian limestones. Even this proportion is much greater in many other parts of the area, owing to the thinness of the sandstone bed in this region. Where the sandstone No. 13 is thick, practically no springs emerge beneath it.

It is noteworthy that this horizon of springs should represent the interval between the Silurian and Carboniferous rocks over a large part of the area. Nos. 11 and 12 are of Silurian age, but they occur only in the eastern part of the area. The fact that this interval is a marked horizon of springs, is probably a coincidence rather than a result of the long time interval, as apparently the only effect it might account for would be the induration of the sandstone of No. 13. There is no unconformity, either of dip or erosion.

The remarkable features of the region are the great number of beautiful springs and the large proportion of them that emerge at definite horizons.

THE AGE OF THE CRYSTALLINE LIMESTONES OF WARREN COUNTY, NEW JERSEY.

By LEWIS G. WESTGATE, Evanston. Ill.

The petrographic characters of certain crystalline limestones of Warren county, New Jersey, have already been described in the AMERICAN GEOLOGIST for last month. It is the purpose of the present paper to consider the evidence of their geological age. These rocks occur in a belt along the eastern border and at the northern end of Jenny Jump mountain. Their more exact location is given in the accompanying map,

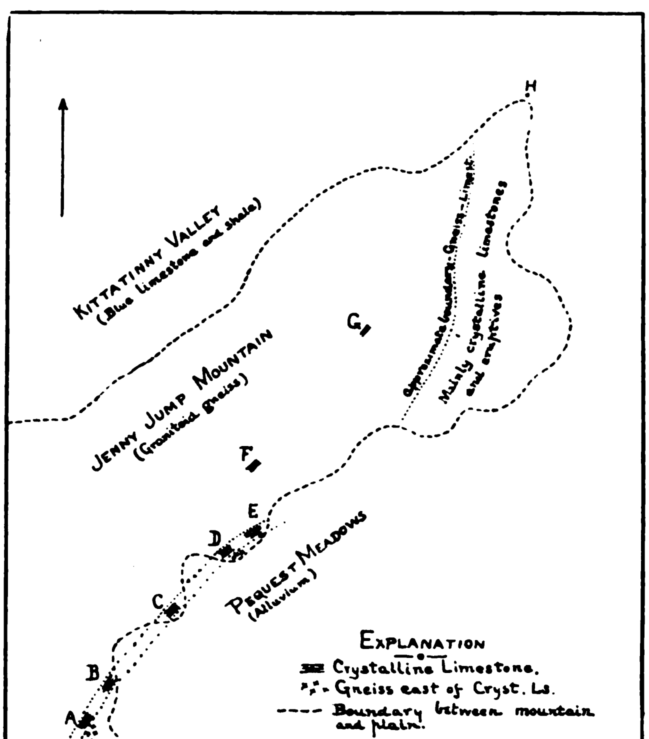


FIG. 1. Map of the northern part of Jenny Jump mountain, New Jersey.

which is based upon field work done while the writer was in the employ of the U. S. Geological Survey. Localities A to E are exposures which, from their alignment and general parallelism of strike, apparently represent a single band of lime-

stone. Localities F and G are small isolated outcrops of crystalline limestone situated in the midst of the granitoid gneisses, which make up the bulk of the mountain. The largest area of crystalline limestone occurs east of the north end of the mountain, occupying an area two miles in length from north to south, and one-half to three-quarters of a mile in width. The surface within this area consists of a succession of low ridges and valleys with no definite order, forming foot-hills lying between the high crystalline mountain mass on the southwest and the alluvium of Pequest meadows on the east.

Petrographical characters of the crystalline limestone and associated eruptive rocks. The crystalline limestones of Warren county are more or less coarsely crystalline, varying between white and red in color, and containing large amounts of accessory metamorphic minerals scattered everywhere through them—mainly pyroxene, hornblende, quartz, and magnetite.

The limestones at the north end of the mountain are cut with great frequency by eruptive rocks. These are of three kinds, diabase, pegmatite, and diorite. Dark, fine-grained diabase, in vertical dikes up to fifty feet in thickness, cuts the limestone at various points. A coarse pegmatite containing considerable amounts of hornblende and magnetite occurs sometimes in irregular areas in the limestone, and is probably of eruptive origin. The most abundant eruptive rocks occurring in the area form a series of varying mineralogical composition, but as a whole merit the name of diorites. They consist generally of green monoclinic hornblende and plagioclase, and are then true diorites. Monoclinic pyroxene often occurs and the rock is then an augite-diorite. In some cases the pyroxene occurs in greater abundance than the hornblende, when the rock becomes a gabbro. While typical diorites are the most common, all gradations occur between the three varieties mentioned. The rocks, however, lack the typical diorite structure. All the principal minerals occur in rounded or polygonal grains. This structure is explained by the fact that the rocks occur in comparatively small masses, and may be supposed to have cooled rapidly, giving no opportunity for the different minerals to crystallize out separately in a defi-

nite order. These dioritic rocks occur in great abundance in the limestone. They are known to be eruptive, because at several localities, where their contact with the limestone can be seen, they branch irregularly out into the limestone. In one or two cases the diorite is distinctly banded not many feet from such eruptive contacts, and were it not that its contact with the limestone proves it to be eruptive, it might easily be mistaken for gneiss. The banding is clearly a secondary structure, and the result of the general metamorphism which the region has suffered.

The relations of the crystalline limestones of Warren county to the crystalline limestones in other parts of New Jersey. Among the crystalline limestones of New Jersey no localities are so well known as those near Franklin, in Sussex county; and writers describing the crystalline limestones of the state have generally had these prominently in mind as typical, and representative of other localities. They have generally considered all the separate outcrops of these beds in New Jersey to be of the same age with the Sussex county rocks. Cook,* in describing the crystalline limestones of the state, considers together the localities in the southeastern and northwestern highlands and places them all in the Azoic (Archæan). Nason,† in describing the Sussex county white limestones, extends the belt by isolated outcrops southward to Jenny Jump mountain and to Oxford Furnace, making all these outcrops of the same age and Cambrian.

The evidence in favor of this correlation of isolated outcrops of crystalline limestone, is mainly lithological, for no fossils have been found in any of the crystalline limestones of New Jersey. The reasons for correlating the crystalline limestones of Jenny Jump mountain with those of Sussex county are as follows: (1) Their likeness in lithological character. The rocks in both regions are very crystalline, generally white or grey limestones, and carry large amounts of accessory metamorphic minerals. (2) In both areas the limestones are cut by similar eruptive rocks—diabase, granite or pegmatite and diorite. (3) In both regions the limestones are more or less closely associated with the granitoid gneisses, which

*Geology of New Jersey, 1868.

†Geol. Survey of N. J., Ann. Rept. State Geol. for 1890, pp. 25-27.

are the most abundant rocks of the northwestern highlands, and in some cases the limestones appear to be interbedded with them. (4) The crystalline limestones at Oxford Furnace and Jenny Jump mountain in Warren county seem to be a southwestward extension of the Sussex county belt. An examination of the geological map of New Jersey does not bring out this supposed relation with any marked distinctness. The Warren county rocks do not appear to be strictly a continuation of the northern belt, but to lie somewhat west of where the southern extension of the Sussex county rocks would naturally be expected.

The crystalline limestones of the two areas have thus been classed together, because of their lithological similarity and their association with the gneisses, and not on good structural or paleontological grounds. Lithological resemblances among crystalline rocks are certainly insufficient proof of contemporaneity. This is especially the case where the areas in question are at considerable distance from each other. In this case the nearest outcrops of the two areas are separated by a distence of sixteen miles. Where no contrary evidence occurs, however, lithological similarity has value as a suggestion; and when, as in the present instance, it is accompanied by association with a similar series of rocks—the granitoid gneisses—and the outcrops occur in a general way in line, it is very possible that the correlation between the two series of rocks which has been made in the past is correct.

Views concerning the age of the crystalline limestones of New Jersey. Two different views have been held as to the age of the crystalline limestones of Sussex county and these views have been extended by their advocates to include the other crystalline limestones of the state. The view which has generally prevailed in the past, is that these limestones are of Archæan age, and are members of the series of crystalline rocks to which the gneissic rocks of the highlands belong and with which the limestones are closely associated. The crystalline structure and the abundant presence of accessory metamorphic minerals, which are characteristics of these limestones, are considered due to the same general causes which have produced a crystalline structure in the gneisses with which they are associated. Among the geologists who have

accepted the Archæan age of these limestones are Vanuxem and Keating,* Kitchell,† Cook,‡ Britton,§ Dana,‖ and H. S. Williams.¶ These writers consider the crystalline limestones to be distinct from the blue Cambrian limestone of Kittatinny valley.

The other view is that these limestones are not true members of the crystalline series, as has generally been supposed, but are of Cambrian age. The supporters of this theory claim that the crystalline limestones belong to the same formation as the blue magnesian limestone (proved Cambrian by its fossils), which outcrops along the eastern border of the Kittatinny valley, and that they have been locally metamorphosed by intrusions of igneous rocks. This view was first proposed by H. D. Rogers in 1840.** It found no further support until Nason†† adopted it, giving a large amount of detailed evidence in its favor. Kemp and Hollick‡‡ accept the same theory for the age of the white crystalline limestones of Warwick, Orange county, N. Y. The reasons given in support of the identity of the crystalline limestone with the blue magnesian limestone, and consequently of the Cambrian age of the former, are, as summarized by Nason,§§ as follows:

1. The white limestones are continuous with the blue limestones (now accepted as of Cambrian age) and every degree of transition may be found between them.

2. Both have the same dip and strike.

3. Both are conformable with a quartzite also containing Cambrian fossils.

---

*Jour. Phila. Acad. Nat. Sci., vol II, pp. 277-288.

†Second Ann. Rept. Geol. Survey of N. J. for 1855, pp. 111-248.

‡Geology of New Jersey, 1868, pp. 309-321, and in later annual reports.

§Ann. Rept. State Geol. for 1885, pp. 36-55. Same for 1886, pp. 74-112.

‖Am. Jour. Sci., III, vol. XLII, 1891, pp. 70-72.

¶Am. Jour. Sci., III, vol. XLVII, 1894, pp. 401-402.

**Final Report of the Geology of N. J., 1840.

††In the Annual Report of the New Jersey Survey for 1890, pp. 25-50. Van Hise in Bulletin 86, U. S. Geol. Survey, "Archean and Algonkian," pp. 399-404, and Nason in AM. GEOLOGIST, vol. VII, pp. 241-252, give a full bibliography of this subject. Other papers by Nason on this subject have since appeared in the AMERICAN GEOLOGIST and in the Bulletin of the Geological Society of America. In the AM. GEOLOGIST for September, 1894, vol. XIV, pp. 161-169, is a summary of the facts brought forward by him to prove the Cambrian age of these crystalline limestones in Sussex county.

‡‡Annals N. Y. Acad. Sci., vol. VII, pp. 638-654.

§§AMERICAN GEOLOGIST, September, 1894, vol. XIV, p. 163.

4. Both are unconformable with the gneiss upon which they rest.

5. Both have in sum total the same chemical composition and are magnesian.

6. The altered crystalline condition of the white limestone is due to the intrusion of igneous masses and to regional metamorphism, while the blue limestone never contains such igneous injections.

7. The presence of certain minerals, especially chondrodite, is not indicative of geological age.

It is not the purpose to consider here the evidence of the age of the white or crystalline limestones of Sussex county, but merely to give the arguments advanced by the different sets of writers. It requires, however, evidence of a very positive paleontological or stratigraphical character to overthrow the generally held opinion that these two very different limestones are of different age.

The age of crystalline limestones of Warren county. The largest area of crystalline limestones in New Jersey, next after that of Sussex county, embraces the Warren county outcrops along Jenny Jump mountain. The facts so far made out by a careful study of the latter, point to the conclusion that these limestones are distinct from the Cambrian blue magnesian limestone which occurs in Kittatinny valley to the west, and that they are of pre-Cambrian age.

Relations of the crystalline limestones to the gneisses. The isolated outcrops, A to E (see the foregoing map), of crystalline limestone along the eastern edge of the mountain, are undoubtedly remnants of what was once a continuous band, and have been separated by erosion, the alluvium of Pequest meadows covering the former connections between the present outcrops. The limestone in these outcrops sometimes shows a faint banding, but very often is quite massive; and when banding is apparently present it is often so obscure that measurements of it are of doubtful value. Where present, the banding of the limestone is in general parallel with that of the gneiss. Granitoid gneiss bounds the limestone on the west wherever outcrops are found on the west side of the limestone. At two points, A and D, banded granitoid gneiss is found on the east of the limestone, between it and Pequest meadows. Rock outcrops are wanting where the gneiss might be expected to be found, east of the other limestone outcrops of this belt. The banding of the limestone agrees

with that of the gneiss on either side. This, with the position of the limestone between gneiss outcrops, seems to indicate that the limestone is interbedded with the granitoid gneiss along the eastern side of the mountain. The intimate association of the limestone with the gneiss is at any rate apparent.

At F and G outcrops of crystalline limestone also occur. At F (just east of the Stinson mine), a band of crystalline limestone occurs in the gneiss, dipping 50° S. E., and with a strike of N. 40° E. This band is about six feet in thickness and is parallel with the banding in the biotite gneiss with which it is associated, and acts in every way as a conformable member of the gneissic series. This outcrop cannot be traced in either direction along the strike, and appears to be local. At G the relations of the limestone are the same. It is not impossible that these two small outcrops may be of the nature of segregations rather than true beds. They are less coarsely crystalline than the other outcrops and contain a considerable amount of basic impurities.

The relations of the northern Jenny Jump limestones will be discussed later. Enough has been said to show that outcrops A to G are closely associated with the gneisses and appear to be interbedded with them.

The crystalline limestones and eruptive rocks. Besides this interrupted band of outcrops, there is, as already described, a large area of crystalline limestone at the northern end of the mountain. The limestone here is cut by numerous eruptive rocks. These are coarse granite or pegmatite, which occurs in large irregular masses; diabase in dikes up to fifty feet in width; and diorite, which is by far the most abundant of the three. These eruptive rocks, however, can not be considered the agent of the metamorphism which has taken place in the limestone. The reasons for this statement are as follows:

(1) If the eruptive rocks were the agents of metamorphism the limestone should be most crystalline at the contact with the eruptive, and should become less crystalline as the distance from the eruptive rock increases, until at no very great distance an unaltered non-crystalline limestone should be found. This limestone should be the same as the blue magnesian limestone of Kittatinny valley, if, as some writers as-

sert, the crystalline limestones are simply the Cambrian metamorphosed by intrusives. Such phenomena as those described are universally present where limestones (or other rocks such as schists or shales) have been locally metamorphosed by intrusives. One of the best known examples of these relations is that at Cortlandt, N. Y., a short distance south of Peekskill. G. H. Williams* in describing the contact here between the eruptive diorites and the limestone, says:

> The metamorphic action extends but a small distance from the actual contact, but is always unmistakable in its nature. The limestone is in almost all cases bleached and is frequently rendered more coarsely crystalline. There are new contact minerals developed in it, among the most common of which are hornblende and pyroxene.

Similar conditions are said by Nason† to occur at the contact of the limestones and eruptive rocks near Franklin, N. J. No such relations occur between the diorites and limestones in the Jenny Jump area. The limestones are not more crystalline at the contact with the eruptives than at a distance from them. The limestone is uniformly crystalline throughout. The accessory minerals, pyroxene, biotite, graphite, etc., are not found more abundantly near the contact than elsewhere. The limestone shows no change in crystalline character, or in the abundance and character of accessory minerals, as the contact with the intrusive is approached.

(2) There are bands of limestone occupying very considerable areas, and everywhere of perfectly crystalline character, which nowhere show the presence of eruptive rocks. The uniformly crystalline character of the limestone over considerable areas is evidence that the metamorphism is not due to local intrusives. It was produced by some cause acting uniformly over wide areas and resulting in regional as distinguished from local metamorphism.

The same relations are shown in the outcrops of crystalline limestone A to G as in the larger area at the northern end of the mountain. Eruptive rocks are of uncommon occurrence in the limestone outcrops along the eastern side of the mountain. At only one locality (B) was an eruptive rock seen in the limestone. Here a small dike of gabbro six inches in thickness was seen cutting the limestone, apparently in the

*Am. Jour. Sci., III, vol. XXXVI, 1888, p. 267.

†Ann. Rept. Geol. Survey N. J., for 1890, p. 32, and elsewhere.

plane of the bedding. Yet these outcrops A to E contain some of the most coarsely and thoroughly crystalline limestone of the whole region and limestone carrying as large a proportion of accessory metamorphic minerals as any elsewhere. The metamorphism cannot be the result of eruptives as there are almost none in the limestone.

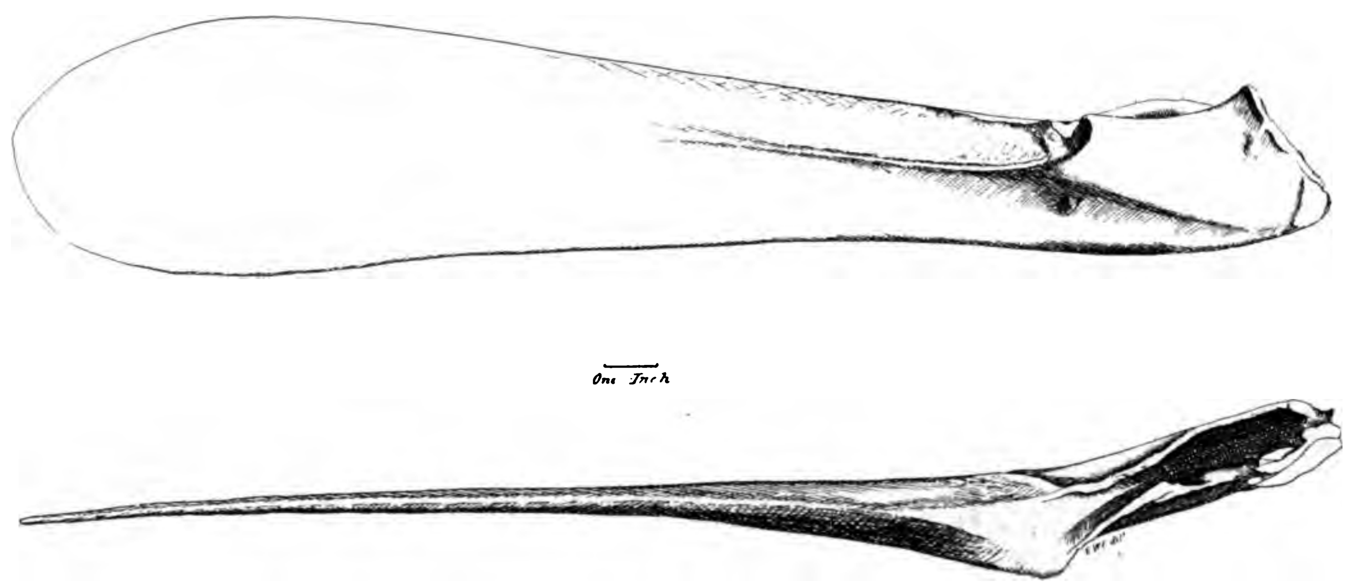
The metamorphism of the Jenny Jump limestones is not local, but general; not due to the agency of eruptive rocks, but to other causes acting over wider areas and producing farther reaching and more uniform effects. In this area the crystalline and the blue Cambrian limestones are not intimately associated. Yet the unchanged blue limestone occurs not far from the crystalline at the most northern outcrops of the latter. The metamorphism has affected the crystalline limestone but not the blue. The reason is clear. The blue magnesian limestone had not been deposited at the time of the metamorphism of the present crystalline limestone, else it too would have been involved in the same changes as have affected the crystalline limestones; changes very probably produced by the same agents that were at work in the crystallization of the associated gneisses. The crystalline limestone is older than the blue Cambrian limestone and is of pre-Cambrian or Archæan age. It is difficult to conceive that the forces resulting in metamorphism could act over considerable areas and then suddenly stop short. If the two apparently different limestones are of the same age, the blue limestone associated with the crystalline should also have been metamorphosed. A greater agent than local metamorphism by eruptives is required, to explain the crystalline character of the Jenny Jump limestones. Regional metamorphism, which is the only adequate explanation of this character, must have occurred at a time previous to the deposition of the blue or Cambrian limestone.

The field relations of the crystalline limestones and the blue magnesian or Cambrian limestone. More or less has been written concerning the field relations of these limestones while discussing previous points of this paper. In the Jenny Jump region they are nowhere in close and intimate association. The two are said to be in intimate association about Franklin, in Sussex county, and that is taken as one of the

evidences of their contemporaneity. The belt of limestone outcrops along the middle of the mountain (A–E) is nowhere in contact with the blue limestone; on the contrary, wherever the rocks adjacent to the limestone on either side appear they are granitoid gneisses.

At the northern end of the mountain the crystalline limestones occupy a distinct area, and no outcrops of blue limestone are known within that area. North of the northern end of this area, however, blue limestone occurs at H (see map), not over two hundred feet from the crystalline limestone. The blue limestone here is the typical fine-grained blue limestone which outcrops further west in Kittatinny valley. The crystalline limestone is in part characteristic for that rock, and in part a local variety (pyroxene-rock or quartz-rock) frequently found associated with the limestone. There are no eruptive rocks cutting the crystalline limestone here. The two outcrops are perfectly characteristic of their respective varieties, and there is no tendency in either toward gradation into the other. It seems hardly possible that the passage should not show in this locality, if there is a gradation between the two rocks, for they are separated by less than two hundred feet. The crystalline limestones of Jenny Jump mountain are in all cases sharply distinct from the blue Cambrian limestones; and at the locality where the two occur nearest together, there is no gradation in lithological character between them.

Conclusion. In conclusion, the crystalline limestones of Warren county are believed to be distinct from and older than the blue magnesian limestone of Cambrian age which occurs along the northwestern side of the New Jersey highlands. They are believed to be distinct for the following reasons: first, they have a well developed crystalline character, and they hold large quantities of accessory metamorphic minerals; second, they show no intimate association in areal distribution with the blue Cambrian limestone; third, they show no tendency to grade into blue limestone. They are believed to be older, because, first, they have been subjected to general metamorphic forces resulting in great changes, of which the neighboring blue limestones show no trace; second, they oc-



BRONTICHTHYS CLARKI.

cur in intimate association with the granitoid gneisses and in some cases appear to be interbedded with them.

Whether the other crystalline limestones of New Jersey are of the same age as those of Warren county, has not been proved. The answer has generally been that they are. This seems to be the most probable view. If they are, and if the position taken in the present paper is valid, then the crystalline limestones of Sussex county, and of other places in New Jersey, would also be, as they have generally been supposed to be, of pre-Cambrian or Archæan age.

[PALÆONTOLOGICAL NOTES FROM BUCHTEL COLLEGE.—No. 8.].

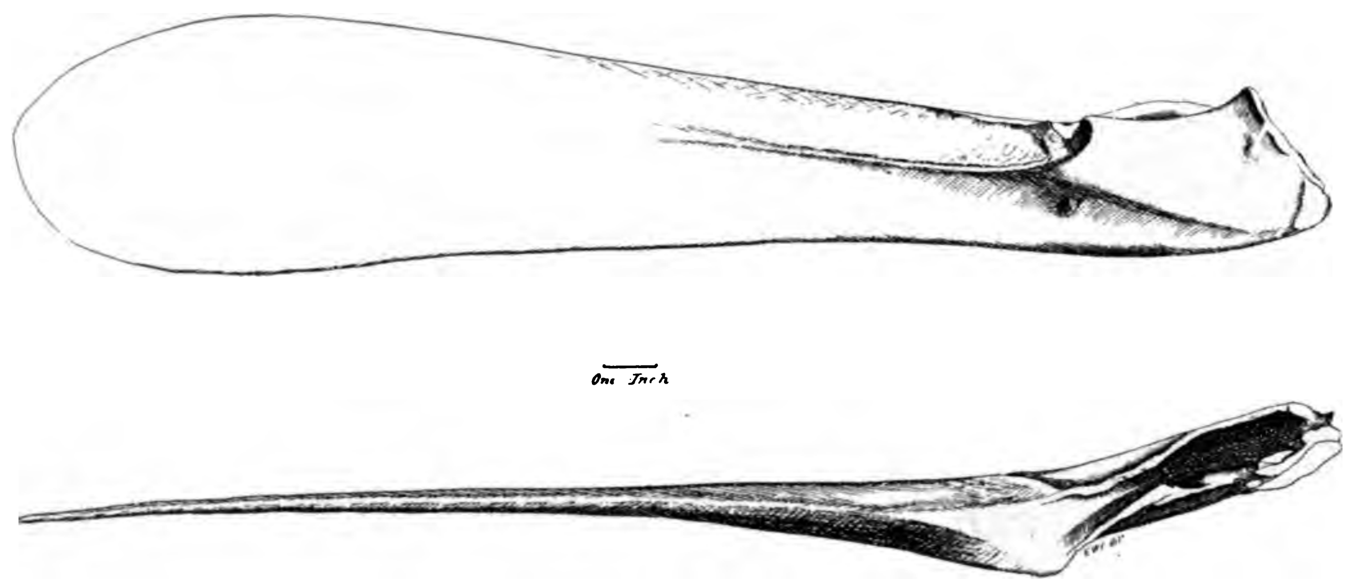
ON A NEW PLACODERM, *BRONTICHTHYS CLARKI*, FROM THE CLEVELAND SHALE.

By E. W. CLAYPOLE, Akron, Ohio.

(Plate XII.)

To the three great placoderms of the Upper Devonian of Ohio, Dinichthys, Titanichthys, and Gorgonichthys, must now be added a fourth genus not less remarkable than the rest and only less striking because it is not the first. In the Cleveland shale of Cuyahoga county Dr. Clark has recently found a jaw, which, while bearing a strong general resemblance to Titanichthys, yet differs so much that it cannot be placed in that genus. Two views of the fossil given herewith will illustrate its characters.

Only a single ramus, the left, was found, and most careful and continuous search failed to discover its mate. It is slightly imperfect on the hinder end but almost complete in front. It must originally have measured at least twenty-five inches from end to end. Its greatest depth toward the spatular end is five inches. In this part it shows no distinction from the jaw of Titanichthys. But in front its construction is much more massive. It bends outward about five inches from the tip, and at the bend begins a deep alveolus resembling that in the jaw of Titanichthys but growing deeper toward the end. This alveolus is now an inch and a half deep, and when its walls were entire it must have been somewhat deeper. The inner wall is rather higher and thicker than the other. It is appa-



BRONTICHTHYS CLARKI.

A NEW PLACODERM FROM THE CLEVELAND SHALE.

Chouteau Limestone group....................	200	
Devonian................................	100	
Upper Silurian..............................	360	
Lower Silurian to the base of the Trenton.....	400	
	——	4,160
OZARK SERIES, including:		
First Magnesian limestone....................	130	
First or Saccharoidal sandstone (St. Peter's)...	130	
Second Magnesian limestone..................	230	
Second sandstone............................	125	
Third Magnesian limestone...............	350 to 600	
Third sandstone..............................	50	
Fourth Magnesian limestone..................	300	
	——	1,315
Total....................................		5,475

Below the Trenton formation in southern Missouri the Ozark series therefore presents a great thickness of magnesian limestone with occasional beds of sandstone. In the well at the Insane Asylum at St. Louis the borings would indicate 2,000 feet of this series. Prof. Swallow applied to them the term "Magnesian Limestone series," but the objection to the term is that there are magnesian limestones of other ages. As the series is well developed in the Ozarks, and the Ozark area is so great, it seems that of all names there is none more appropriate than "Ozark Series." As such I have named and described it in an article published in the AMERICAN GEOLOGIST for July, 1891.

In southeastern Missouri the continuity of the Ozark series is not preserved in the same manner as represented elsewhere, but is thus:

First Magnesian limestone..........................	130
First or Saccharoidal sandstone......................	133
Second Magnesian limestone.........................	175
Second sandstone; lower beds cherty..................	125
Third Magnesian limestone with chert and quartz....	225
Gritstone and *Lingula* beds..........................	50
Ozark marble.......................................	25
Lower sandstone and conglomerate..................	90
Total..	953

These rest on the Archæan porphyries and granite. The thickest development of the terranes between the Ozark series and the top of the Lower Carboniferous Dr. Shumard has estimated to be over 1,800 feet in Cape Girardeau county. He

recognized over 600 feet of Upper Silurian in that county. Northwardly it becomes thinner, not being observed at all in St. Louis, St. Charles and Jefferson counties, but may be 100 feet thick in Pike county. In Montgomery county about 20 feet of gray limestone may be referred to the Upper Silurian, and this is restricted to a small area in Montgomery and Callaway counties. Certain terranes being wanting in central and southwestern Missouri the Paleozoic rocks, in their areal distribution, would have much less average thickness than the section above gives.

In southwest Missouri the group between the St. Louis and Chouteau cannot well be separated. To such Prof. H. S. Williams has appropriately given the name "Osage series."

The Ozarks belong to Missouri and in part to Arkansas. The Boston mountains are of another system, extending westwardly into the Indian territory. Farther south is the Washita system, extending from Little Rock west to the western part of the Indian territory. The area of Missouri, according to the census of 1890, is 69,415 square miles. Most of southern Missouri is included in the Ozark plateau, an elevated tract which in Missouri contains about 36,000 square miles; and its total area is probably 50,000 square miles, including part of Arkansas. This plateau is limited on the east by the Mississippi; on the north by the Missouri and Osage rivers; and on the west by a line about 30 miles east of the western state line. The Arkansas river may be the southern limit. The eastern portion of north Missouri is elevated about 700 feet above the sea; passing westwardly it rises by gentle undulations to 1,100 and 1,200 feet in the northwest. The Ozark plateau near its eastern border is 700 to 800 feet above the sea, but within 30 miles it rises to 1,200 and 1,500 feet. The porphyry peaks of southeastern Missouri rise 1,200 to 1,800 feet above the sea, while the unaltered sedimentary rocks surrounding them rest unconformably upon them at an elevation of 1,100 to 1,200 feet above the sea. Passing westwardly they rise to 1,500 feet in Webster county, 1,700 in Wright, 1,350 in Green, 1,530 in Barry county, and nearly 2,000 feet in the Boston mountains of northwestern Arkansas. Along the western state line the elevation is 850 to 1,100 feet, while beyond in Kansas the country gradually rises to the plains and

to the Rocky mountains beyond. In southern Illinois the general surface is but little over 500 feet, reaching 700 and 800 feet in the central portion. Borings at the Insane Asylum, St. Louis, would indicate that the Archæan lies about 3,800 feet below the surface, or about 3,200 feet below the sea level. Not altogether reliable records of a Jackson county boring assert that granite was reached there about 2,500 feet below the surface, or 1,500 to 1,700 below the sea level. From observed outcrops in central and southwestern Missouri we would suppose that borings in Nodaway county might penetrate through 4,000 feet of strata to reach the Archæan, finding it about 2,800 feet below the sea. That would nearly agree with the measured depth at St. Louis. The Archæan floor in southern Illinois probably occupies about the same position below the sea that it does at St. Louis. At the close of Archæan time the state would be occupied by a deep sea, the Cambrian sea, through which in southeastern Missouri certain granite and porphyry peaks protruded 500 to 1,000 feet above the waters; these are now seen in St. Francois, Madison, Iron, Reynolds and Wayne counties. Southeastern Missouri was probably dry land in the early Cambrian, but in the later Cambrian or early Potsdam period the Ozarks were occupied by a shallow sea whose waves dashed furiously against the Archæan hills, sufficient to erode enough material to form a sandstone. This sandstone is found upon a limited area in about four counties of southeastern Missouri. It is generally of coarse texture and includes pebbles of the Archæan. Elsewhere the strata are covered with more recent deposits. Most of the Archæan area subsided to a depth of 2,000 to 3,000 feet in order to receive the Lower Magnesian limestone and interbedded sandstones of the Mississippi valley, extending from central Texas to lake Superior; only certain peaks in Llano and Burnet counties, Texas, and in six or seven counties of southeastern Missouri were exposed.

The life of this early Cambrian sea was limited in number of species. In Missouri it embraced a few Orthocerata, a Lituites, a small Orthis, a Pleurotomaria, a Maclurea, an Ophileta, two or three species of Straparollus, probably two species of Murchisonia, and three or four species of trilobites; while in the Potsdam of Wisconsin and Minnesota several

other species of trilobites have been found. Sea worms abounded where the waters were more shallow, and left their tracks in irregular winding holes in the off-shore sandstone. In the upper beds sea weeds abounded, as shown by the limestones now exposed. Certain beds of the Second Magnesian limestone are largely made up of the accumulated mass of sea weeds bundled and pressed together, their form only preserved, filled with calcareous matter.

There were occasionally elevations long enough continued for sands to accumulate off-shore to become in later time beds of sandstone, then a sinking and accumulation of sediment in the deeper seas, until finally 2,000 feet had been formed. Ages rolled on, the ocean beds rose, the granite and porphyry hills of southeastern Missouri, as well as those of Wisconsin and Minnesota, were eroded of their material during the violent agitation of the waters near the close of the period of the Upper Cambrian. These sands were deposited around the sea's margin in remarkably clear water. The First sandstone, or the St. Peter's, was formed thicker along the Mississippi trough, or what was afterward the Mississippi trough, extending from southeastern Missouri to St. Paul in Minnesota. East and west of that line the deposit is thinner, apparently entirely thinning out in Missouri at 160 miles west.

After the laying down of this sandstone most of the Ozarks were raised above water. Much of the upper strata were eroded and redeposited to form the rocks of later ages. The evidence is that after the Upper Cambrian period most of the Ozarks were elevated above the waters and have so remained. The Ozark series northward and eastward was depressed not less than 1,500 feet, and the Ozarks were separated from the Wisconsin highlands by a deep sea; this was the Silurian sea, and in it were laid down the Trenton and Hudson River beds toward the north and east. But this condition prevailed only as far west as Callaway county. From this we infer that the Ozarks at that time extended over the western and northwestern part of Missouri. After the Lower Silurian was formed the western half of Missouri was dry land, but the country from Cape Girardeau to Ralls county was so depressed as to receive from 100 to 200 feet of sediment to form the Upper Silurian. Eastwardly the bottom gradually settled

down sufficiently to receive 3,000 feet of sediment in the Appalachians and New York. but this thinned out as above stated to 200 feet in southeastern Missouri, becoming zero in Callaway county. Westwardly dry land continued. The subsidence continued so as to receive about 100 feet of Devonian limestone in northern Missouri, thinning out in Pettis county. The Devonian sea extended northwardly to Wisconsin and around the eastern slopes of the Ozarks and beyond the Appalachians. Upon the Ozarks, and extending far west, dry land still prevailed. At the close of the Devonian on the east and south a clay deposit accumulated in certain shallow estuaries, which later by the absorption of certain hydrocarbons became a black slate. The Devonian period in Kentucky and in a portion of Missouri, notably at the falls of Ohio and in Callaway county, Mo., was characterized by extensive coral reefs. The Upper Silurian and Devonian in the eastern states were also rich in coral forms.

After the Devonian was laid down there seems to have been a marked dynamic change. At the close of the Devonian there was a subsidence of most of the Mississippi valley west of the Mississippi river, with the exception of Minnesota and part of Iowa, and the Archæan of southeastern Missouri and of Texas. The Ozarks subsided sufficiently for the early Carboniferous seas to cover their margins. This was the beginning of the Subcarboniferous. On the east and north these beds rest upon the Devonian, but on the west they repose upon the Ozark series. The several groups of the Subcarboniferous, as the Paleozoic sea sank, continued to gradually accumulate. First the Chouteau and its several formations, next the Burlington with its rich crinoidal fauna and intercalated chert, then the Keokuk, and then the St. Louis,—each to be afterward in a great measure eroded. That there was a slight subsidence and then an elevation of the Ozarks after the Burlington had accumulated is shown by the occasional finding of patches of limestone of that terrane along the northern and western front and resting upon the Ozark series, indicating that the erosion of the early Subcarboniferous must have been great. Previous to this, the erosion of the later Ozark series must also have been great, but very probably it was largely aërial. Since the close of the Burlington the

Ozarks have remained above water. The accumulations of the St. Louis and Chester limestones were greater along the Mississippi, and thin out westwardly. The later Chester or Kaskaskia limestone was represented only by a sandstone in northern and southwestern Missouri. At this time there was a marked change in fauna and flora, as well as in continental area. The deep ocean floor, east, north and west of the Ozarks, which had been so long receiving deep sea deposits sufficiently to be part land, part water, rose with a surface nearly flat, over which were lakes and vast swamps, beginning to support a rare and luxuriant vegetable growth, the forerunner of the coal period. The leaves and older trees fell and accumulated in the peaty swamps and in time were covered by the overflowing seas, leaving silt and sediment. Soils were formed; forests grew and matured, and lycopods and ferns* left their debris to be again covered up. At one time the surface would sink so much that the overflowing sea covered the older beds with accumulations of limestone. In this way a number of ancient forest beds with their vegetable growth were buried. Each of the beds of decaying vegetation was converted to coal; the same vegetation in the presence of the atmosphere would form humus. That there was probably a great deal of carbonic acid in the atmosphere during the coal period is believed; also that this was absorbed or withdrawn by the luxuriant plant growth. While these deposits were being formed, a large portion of the Mississippi valley was sinking. Still the Ozarks kept their everlasting hills above the waters, while Kentucky, Indiana, Illinois, Iowa, northern Missouri, Arkansas and Texas were nearly covered by coal swamps, over which the sea would occasionally flow.

During the formation of the coal in the Appalachians and the Mississippi valley, and while the country in general was being subjected to alternate depression and elevation, the present Rocky mountain region remained for the most part under a deep sea. The coal of the west is of more recent age. In that region, during the time of the Upper Carboniferous period, limestones were chiefly formed in the deep seas. We

*[NOTE. At present we may have about 15 species of living ferns in Missouri. In Henry county over 40 species have been obtained from the shales overlying the coal beds, all pressed and beautifully preserved in nature's herbarium.]

have found an occasional plant fragment, showing that there may have been a few Carboniferous islands supporting a lycopodiaceous growth. But there is no coal of Carboniferous age west of the plains. Around the margin of the lower Coal Measures, where they rest upon rocks of older terranes, are found isolated coal deposits consisting, for the most part, of an impure cannel or bituminous coal. Their thickness may be a few feet or may be 20 or 50 feet, or even more; their inclination to the horizon would indicate that they were formed when the adjacent strata were considerably disturbed, or that a disturbance occurred soon after the coal was laid down. These beds are now often found in side valleys tributary to larger valleys; and the rocks higher in the hills as well as those on which the coal rests are of older age than the coal itself. In fact they rarely extend farther than 200 feet into the adjoining hill. In northeastern Missouri they lie on and against the Lower Carboniferous; in Cole, Moniteau and Morgan counties they rest on beds of the Ozark series, and in no instance have I observed them occupying eroded valleys of Upper Carboniferous age. They must have been formed just at the dawn of the Upper Carboniferous when there was an unsettled condition existing, and when oscillations and tilting of strata prevented a continuous coal formation; or in other words the first coals were laid down in small disconnected basins.*

We have thus far traced the geological history of each terrane. We would now consider briefly the subsequent fracture, erosion and carrying away of the material so as to prepare our field for man's habitation.

At the close of the Paleozoic the Appalachian revolution took place; the coal and other interstratified beds from Pennsylvania and southwestward to Alabama were crushed up, folded, and raised 4,000 or 5,000 feet; and the bituminous coal of eastern Pennsylvania was changed to anthracite. At the same time there was a slight quaquaversal upthrust of the Ozarks and of the later strata, as shown by occasional

*Both zinc and lead ores have been found with the coal in these "pockets," evidently deposited since the coal was laid down; and it may be that the lead and zinc ores of central and southwestern Missouri were all deposited since the laying down of the coal.

slight fractures and faultings. That was the last uplift of the Ozarks. Previously there were undoubtedly stream channels in the Ozarks. After the close of the Paleozoic there were additional fractures, greater erosions and deeper channelings by the streams. In southern Missouri the eroded valleys are 300 to 450 feet deep, in northern Missouri they may have been 200 or 300 feet, but, excepting near the Missouri river, they are rarely to be seen over 150 feet deep, reaching 200 at the extreme. The Missouri river shows a valley generally one to two miles wide, with an inner channel or trough eroded before glacial times but during the Ice age filled up from 40 to 90 feet.

Proportional to the size of the stream and character of the bluff are the size and depth of the stream's trough. The streams in southern Missouri are partly filled with a local drift. Away from the larger streams the country is hilly or rolling, dependent on the character of the rock structure. Where the country rock is limestone, the channels and hills are rugged. The Coal Measures being largely composed of sandstones and shales, with only thin limestone beds, the erosion there has been greater, but the slopes are more gentle. We often observe limestone-capped ridges; when the erosion is long continued they remain as mounds. To this is due the interesting and beautiful scenery of the prairies of western Missouri. Where the strata consist of beds of shales and sandstone capped by harder limestone, the last serves as a protecting cap to the softer underlying beds, retarding their entire erosion. A line of such mounds may be traced along the base of the upper Coal Measures from Bates county northeastward through Cass, Johnson, Lafayette, and thence northwardly. Along this line are seen ridges several miles long, and occasionally a single mound 80 or 100 feet above the lower plains with an area of probably half an acre on the summit. Other mounds may be near, or distant two, five, or fifteen miles. The visible depressed or eroded area may be a prismoid 100 feet deep by five or ten miles in one direction and twenty miles or more in another. From the summit of one of these mounds we may gaze on a hundred farms occupied by an industrious and thrifty people.

EDITORIAL COMMENT.

A NEW METEORITE. MINNESOTA No. 1.

Last April (9th), about four o'clock in the afternoon, a peculiar rumbling sound startled the people in the neighborhood of Fisher, in Polk county, in the Red river valley, in the northwestern part of Minnesota. In July, in making hay on a meadow in Sec. 28, Range 49, T. 150, a stone was found which had by falling entered the sod a few inches, the force of the impact having turned the turf back in all directions. There being no drift boulders on the surface in the region, this was at once connected with the rumbling noise. On examination it proves to be a chondritic meteoric stone, quite similar to the well known Winnebago meteorite. Its weight is about 9½ pounds, and it is entirely covered with the usual black crust. This being the first known meteorite fallen in the state it is proposed to name it *Minnesota No. 1*, with a view to continue the series by suitable numeration for all future Minnesota meteorites. A full description will be given in a later issue of the GEOLOGIST. N. H. W.

ARCTIC AND ANTARCTIC EXPLORATION.

In a paper read before the Section of Geography in the British Association at the last August meeting,* Col. H. W. Fielden, who was the naturalist of the Nares Arctic Expedition in 1875-'76, reviewed the reasons for hoping and expecting that Nansen and his party, after drifting in the ice-pack across the sea surrounding the north pole, will return to tell their experiences. Not only is Siberian drift-wood strown along the northwest coast of Greenland and the shores of Grinnell land, but also the currents have brought such drift-wood during a long time past, in which Grinnell land has been uplifted at least 1,000 feet. Up to that hight, Col. Fielden there found drift-wood embedded in recent alluvial or glacial clay and mud deposits, with marine shells of the species now living in the adjoining sea. The bivalve shells are often still held together by their hinges and retain their brown epidermis; and the wood is combustible and so light as to float on water. All the wood appears to be of coniferous species, be-

*Partly printed in the Bulletin of the American Geographical Society, New York, vol. XXVI, pp. 389-393, Sept. 30, 1894.

ing wholly different from the drift-wood cast on the shores of Spitzbergen, which is borne by the Gulf Stream into the North Atlantic and Arctic oceans.

We may add, in this connection, that Gen. A. W. Greely's Report of the U. S. Expedition to Lady Franklin bay, Grinnell land, mentions (in vol. II, p. 57) the occurrence there of recent fossil shells of *Astarte lactea* up to 1,000 feet, and of *Saxicava arctica*, as provisionally determined, up to 2,000 feet above the sea. At Polaris bay on the neighboring Greenland coast, recent marine shells are reported to occur at the hight of 1,600 feet.

It may be also noted that one of the questions which we may hope to have answered, if Nansen crosses the polar sea and reaches home, relates to the geographic position and extent of the large nearly flat land from which come the great tabular icebergs, sometimes called floebergs and "palæocrystic icebergs," similar to the vast masses shed from the Antarctic ice-sheet, though smaller, ranging from 100 to 600 feet and rarely 800 or 900 feet in thickness, seen by Nares and others in the open polar sea north of Greenland and Grinnell land. These flat icebergs, born from the margin of an ice-sheet on flat and comparatively low land, unlike that of the Greenland ice-sheet and its valley glaciers, are thought by Greely to come from a large land area north of Bering strait and very near the pole, with its center between the 86th and 88th parallels and the 155th and 175th meridians of west longitude. The thick tabular bergs are prevented from drifting to the Siberian coast by the shallowness of the sea there; but they are carried by the currents to Banks land, Grinnell land, and into Robeson and Kennedy channels, where the Atlantic tides sweeping around the north end of Greenland turn south to Smith sound.

Numerous glaciers by which the Greenland ice-sheet outflows through the valleys of its mountain border into Melville bay and Inglefield gulf, between 75° and 78° north latitude, are described by Prof. Angelo Heilprin.* Among the illustrations accompanying his paper, the most interesting are the "hanging glacier" of Herschel's island, flowing down from the

*Popular Science Monthly, vol. XLVI, pp. 1-14, with nine illustrations from photographs, Nov., 1894.

crest of a high mountainous coast, and a "domed glacier" in Inglefield gulf, having the form of a great roundly sloping alluvial fan, with its border broken off in steep cliffs by the sea. Prof. Heilprin ventures the opinion that exploration and study of the Greenland glaciers will probably bring "no explanations that have not already been made familiar through the teachings of other countries." Glacialists, however, will be more hopeful, since our literature and resources for theories have been so increased by Russell's studies, in 1890 and 1891, of the Malaspina glacier or ice-sheet in Alaska. Much new light is expected, by investigators of the glacial drift and its problems, from the past summer's observations of the Greenland ice-sheet and glaciers by Chamberlin and Wright, supplementing the previous observations of Rink, Holst, Steenstrup, Nördenskiöld, Nansen, Peary, and others.

Furthermore, it is to be earnestly desired that an expedition on the Antartic ice-sheet shall be undertaken, and it seems possible that a great part or perhaps nearly all of the distance of 850 miles from the shore near the high volcanoes Terror and Erebus to the pole can be traversed, with a safe return, during the three months of the circumpolar midsummer available for such an expedition. It would be very instructive to learn whether the maximum central altitude of the ice surface in Greenland, about 9,000 feet where it has been crossed by Nansen and Peary, is exceeded by the far more extensive Antarctic polar ice-cap. Nunataks, or the tops of hills and mountains projecting above the ice-sheet, are found in Greenland only near its borders; but the Antarctic continent, while having chiefly a low margin, may contain very high mountains, rising out of the ice as nunataks far toward the south pole.

W. U.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Laramie and the overlying Livingston Formation in Montana. By W. H. WEED. With *Report on Flora*, by F. H. KNOWLTON. (U. S. Geol. Survey, Bulletin 105. 68 pp.; 6 plates. 1893. Price, 10 cents.) There are few western formations around which there has been so much dis-

cussion as the Laramie, and there are few concerning which there are still so many questions of interest undecided. As has long been known, the correct delimitation of this formation is a matter attended with some difficulty. It has been thought that the Laramie strata represent unbroken sedimentation from the Cretaceous into the Eocene. Cross, Eldridge, and Hills, have shown that there is in Colorado a series of post-Laramie beds of considerable extent, which are separated from the true Laramie by marked unconformity. It has been found that many of the plant remains, supposed to represent the Laramie, in reality belong to the Denver and correlated beds. The necessity of a careful revision of these forms has been insisted on. Similar beds and relations have been found in Canada. These facts impart a considerable interest to the results obtained by a study of the intervening Montana field.

In brief, Mr. Weed finds near Livingston, Montana, overlying the coal-bearing Laramie strata and underlying the Fort Union beds, a vast series of sandstones, grits, clays, and agglomerates, aggregating some 7,000 feet in thickness. This series is separated from the true Laramie by unconformity, and is characterized by a distinct flora. It consists of upper and lower beds, between which is intercalated, over a portion of the field, a 2,000 foot bed of subaërial, volcanic agglomerates, composed mainly of andesitic lavas.

The evidence of unconformity consists of observations by Dr. A. C. Peale near Sphinx mountain, where the beds referred to the Livingston were seen to rest in angular unconformity upon the Dakota sandstone; certain irregularities in the thickness of the Laramie; and the presence in the Livingston of pebbles derived from all the earlier formations, whereas the Laramie contains Archean debris only. From these observations it is inferred that when the Laramie beds were being deposited Archean land only was exposed, but that before the Livingston epoch the land was elevated and during that epoch all the earlier beds were undergoing erosion. The debris, mixed in part with andesitic lavas from the neighboring volcanoes, was laid down in an inland lake.

Mr. Knowlton has carefully revised all the plants from these beds; a work of considerable difficulty and necessity. In all he finds some 44 species. Of these 5 are new, and 11 are not found elsewhere. Of the remainder 22 are Livingston forms, 2 Laramie proper, and 4 common to both. Of the 22 species having distribution outside of this area, 17 are exclusively Denver forms or have their greatest development in that formation.

The Fort Union beds are recognized as Eocene on both stratigraphic and paleontologic data. H. F. B.

Geology of the Big Stone Gap Coal Field of Virginia and Kentucky. By Marius R. Campbell. (U. S. Geol. Survey, Bulletin 111. 106 pp.; 6 plates, and 3 figures in the text. 1893. Price, 15 cents.) The area studied and described in this report is one which, although long famous in history and more recently familiar to the tourist, has been almost unknown geologically. The Carboniferous strata of Pennsylvania, Ohio,

and portions of West Virginia and Alabama, have been studied in considerable detail: but outside of these regions little detailed work has been done in the Appalachian coal basin. The Big Stone Gap coal field is one of great economic possibilities. There is present a very full section of the Carboniferous series, aggregating 7,000 feet in thickness. The author has recognized seven different formations, to which local geographic names have been given as follows, in their descending order:

Harlan sandstone	880	feet.
Wise formation	1,270	"
Gladeville sandstone	100	"
Norton formation	1,280	"
Lee conglomerate	1,200 to 1,600	"
Pennington shale	900 to 1,100	"
Newman limestone	930	"

These are apparently differentiated on their lithologic character and order of superposition. The Harlan and Gladeville sandstones and the Lee conglomerate serve as key rocks in the interpretation of the complex faulted structure. Four productive horizons are recognized: (1) at the base of the Harlan sandstone; (2) directly above the Gladeville sandstone; (3) in the Imboden and Crab Orchard basins at a lower horizon extending from the Imboden to the Cannal seam; (4) in the Guest river basin the productive horizon extends from the Imboden seam to within 200 feet of the Norton formation.

With the vast unstudied regions intervening between this and other fields of known stratigraphy, it is recognized that for the present the Big Stone Gap section must stand almost wholly alone and only general correlations are now possible. The Lee conglomerate can be pretty closely correlated with the Pottsville series; the Pennington shale and the Newman limestone represent the Mississippian series; while the Gladeville and Mahoning sandstones are probably equivalent, as may also be the Harlan and the Wanesburg. Accepting these correlations the following interesting comparisons become possible:

	W. Va.	Big Stone Gap.	Cahaba.
Permo-Carboniferous	1,162	880	480
Intermediate measures	2,098	3,650	3,240
Conglomerate	1,400	1,500	1,765

The report is illustrated by a geologic and topographic map, and by a unique contour map of the upper surface of the Gladeville sandstone; the latter is designed as an especial aid in the location of the coal seams.

In connection with this bulletin it is of interest to read a recent paper* by the same author in which the history of the drainage system of the region is admirably elaborated. H. F. B.

The Glaciation of the Yellowstone Valley north of the Park. By W. H. WEED. (U. S. Geol. Survey, Bulletin 104. 41 pp.: 4 plates. 1893. Price, 5 cents.) From the extensive system of alpine glaciers covering the greater part of the Yellowstone National Park, a valley glacier is found to have reached 36 miles northward down the Yellowstone river

*Am. Jour. Sci., III, vol. XLVIII, pp. 21-29, 1894.

beyond the Park boundary. "Throughout the entire field the higher mountain peaks rose above the névé fields, though the high plateaux and broader mountain summits show considerable glacial abrasion and were unquestionably covered by moving ice." The evidences of the glaciation are, as usual, rounded and striated rock surfaces; the broadening of cañons; transportation of boulders, sometimes from lower to higher elevations; the formation of moraines, kames, and valley gravel deposits, remnants of the last being now conspicuous river terraces; and the cutting of cañons transverse to the mountain slopes and drainages in front of the glacier's termination. A very striking contrast is noticeable between the glaciated and unglaciated portions of the region.

W. U.

The Paleozoic Section in the vicinity of Three Forks, Montana. By A. C. PEALE. With *Petrographic Notes*, by G. P. MERRILL. (U.S. Geol. Survey, Bulletin 110. 56 pp.; 6 plates, and two figures in the text. 1893. Price, 10 cents.) The section here described, between the East Gallatin and Missouri rivers, consists of Carboniferous, Devonian, and Cambrian strata, as determined by their fossils, aggregating nearly 10,000 feet in thickness, thrown into steep, northwestwardly dipping folds, and resting on Archæan gneiss. Mr. Merrill describes rock specimens from the Archæan base of this section; from the next overlying Belt formation of micaceous sandstones and conglomerates, slates, and bands of silicious limestones, regarded as of Algonkian age; and from intrusive sheets in the Flathead shales, the lowest member of the fossiliferous Paleozoic series and the only one of its six formations which is traversed by eruptive rocks.

W. U.

Annual Report of the Geological Survey of Arkansas for 1891 (1894). *Vol. II, cloth, pp. x and 349.* J. C. BRANNER, State Geologist, Little Rock.

This volume contains, with a colored geological map of Benton county, the following parts: The geology of Benton county, by F. W. Simonds and T. C. Hopkins; Elevations in the state of Arkansas, by J. C. Branner; Observations on erosion above Little Rock, J. C. Branner; Magnetic observations, J. C. Branner; The Mollusca of Arkansas, F. A. Sampson; The Myriapoda of Arkansas, by C. H. Bollman; The fishes of Arkansas, by Seth E. Meek; The geology of Dallas county, by C. E. Siebenthal; Bibliography of the geology of Arkansas, by J. C. Branner. The geology of Dallas county is accompanied by a contoured sketch-map of the county, the contour interval being 50 feet.

N. H. W.

Annual Report of the Geological Survey of Arkansas for 1892 (1894). Vol. II, cloth, pp. xvi and 207. J. C. BRANNER, State Geologist, Little Rock. *The Tertiary Geology of southern Arkansas*, by GILBERT D. HARRIS, with a colored geological map. In a peculiarly difficult and unfavorable region Prof. Harris has succeeded in making a valuable contribution to the geology of Arkansas and adjoining states, in which all students of the American Cenozoic will take interest. The Eocene series is made to consist of the following parts, in descending order: Jackson stage, Clai-

borne stage, Lignitic stage, and Midway stage, "all capped by shore deposits, some of which evidently date back to the age of the underlying beds, while others have been subsequently re-arranged. The orange sand of Hilgard, in part at least the Lafayette formation, as understood by McGee." Much of the re-arrangement mentioned "presumably took place before the close of the epoch represented by the underlying stratified beds." N. H. W.

The United States; facts and figures illustrating the physical geography of the country and its material resources. Supplement 1. Population, immigration and irrigation. By J. D. WHITNEY. (Boston: Little, Brown & Company. 8vo, xxvii and 324 pp., 1894.) This volume is considered a supplement to that which was issued about 1890, which was a corrected and enlarged republication of Prof. Whitney's article originally written for the Encyclopedia Britannica. The present volume contains scientific and statistical information made available through the census of 1890, with concise statements of various scientific and economical problems involved in the increase and distribution of the population, the influence of irrigation and the possibility of changing the climate by the agency of man. It is specially full on irrigation. The author gives general descriptions of the various irrigable areas and considers the adaptability of each to methods by reservoirs or by artesian wells. This implies a discussion of their geological character and of all their physical features. The author reviews various irrigation reports, and gives lists of all government reports on irrigation. N. H. W.

The Proceedings of the Indiana Academy of Science for 1893 (published Aug., 1894) contains two papers of interest to geologists: one a bibliography of the geology of Indiana by Prof. V. F. MARSTERS and E. M. KINDLE, Instructor at the Indiana University; and the other a paper by Prof. R. ELLSWORTH CALL, upon the indurated Tertiary rocks of northeastern Arkansas. The bibliography will be found useful to geologists outside of the state as well as inside of it, for besides the usual authors' list it contains topical heads, such as coal, gas, oil, Quaternary, etc. In some cases the arrangement of titles is a little confusing, as where "Dubois county" is followed by a subdivision of the bibliography under the head of "Economic geology," and where "Stone" is followed by "Elkhart." This, however, is probably only a typographic error. The authors of this valuable paper will find a few additional titles in the annual reports of the Indiana State Board of Agriculture (e. g. 1853, pp. 299-332), and in Owen's "Reconnoissance" made in 1837, and published in 1859.

The subject of especial interest in Prof. Call's paper is that of subaërial or surface metamorphism. The sandstones of Crowley's ridge in Arkansas are, for the most part, very soft and friable, but they were found by Call to have been changed locally into the hardest kind of quartzites. In hand specimens, and even in the field, these rocks resemble Paleozoic quartzites so closely that such an excellent observer as Dr. Owen mentions them in his "first survey" of Arkansas as Paleo-

zoic. The work done by Prof. Call shows that these sandstones are Tertiary, and that the quartzites are local variations of them. By what process this change has come about the author does not attempt to explain. A microscopical examination of the rock might throw some light on the subject.

Established in 1885, the Indiana Academy of Science has grown at a remarkable rate. At the head of its list of members stands the name of the astronomer Daniel Kirkwood, and this is followed by those of Jordan, Mendenhall, Gray, Campbell, Coulter, Gilbert, Evermann, and a host of others equally well known. It is hoped that with this third volume of its Proceedings the Academy has passed its "second summer," and that it will be able to maintain and improve a publication which reflects so much credit upon the whole state of Indiana. J. C. B.

Some Typical Eskers of southern New England. By J. B. WOODWORTH. (Proceedings of the Boston Society of Natural History, vol. XXVI, pp. 197-220, with five figures in the text; April, 1894.) This paper describes the physical features and discusses the origin of eskers examined by the author during his work of mapping the Pleistocene deposits of portions of Massachusetts, Rhode Island, and Connecticut, for the U. S. Geological Survey. The term *eskers* is employed to designate the elongated ridges of gravel and sand, often serpentine in their courses, which were deposited in channels of drainage upon, in, or beneath the waning ice-sheet; while the term *kames*, in accordance with the suggestions of Chamberlin and McGee, is restricted to mounds and disconnected short ridges of similar gravel and sand, probably marking the mouths of small glacial streams and usually associated with moraines or with plains of stratified drift. The eskers are mainly referred by Mr. Woodworth to a subglacial origin, although he believes that in some instances portions of their courses indicate deposition in a channel open to the sky, where the ice roof had been melted through. Bibliographic references are quite fully noted, with quotations of the views of previous writers on this subject, some of whom, as N. H. Winchell, Upham, and Holst, think eskers more commonly to have been superglacial, being deposited in ice cañons and deriving their material from englacial and finally superglacial drift. Highly significant recent studies by Barton of channels on drumlins in Massachusetts (AM. GEOLOGIST, March, 1894, p. 224, and Am. Jour. Sci., Oct. 1894, p. 349) seem to prove that many esker-forming streams were superglacial or englacial and could not have been subglacial. W. U.

On the Distribution of Earthquakes in the United States since the close of the Glacial period. By N. S. SHALER. (Proceedings, Boston Soc. Nat. Hist., vol. XXVI, pp. 246-256; read Jan. 17, 1894.) Boulders lying in unstable positions on the rocky shores of Maine and northeastern Massachusetts, occasional pinnacles of rock spared by erosion and liable to be easily thrown down, and the steep hillocks and ridges of loose glacial gravel and sand called kames, all occurring in the New England states near the sea level and within reach of the great wave which would be

produced by a powerful submarine earthquake, show that no such wave has swept upon that coast since the Glacial period. On Long Island and south to Florida the extensive beach ridges of sand, separated from the main shore by long and shallow bays and sounds, are also shown by Prof. Shaler to indicate similar long immunity from earthquake sea-waves. Likewise through large regions in the interior of the United States, the occurrence of delicately poised boulders, and, south of the drift area, the unstable rock-cliffs and columnar or tower-like remnants of eroded strata, and insecurely pendent stalactites in caverns, testify of long quietude, unbroken by earthquake shocks, at least during the "ten thousand years or more" since the Ice age. W. U.

The Geographical Development of Alluvial River Terraces. By R. E. DODGE. (Proc. Boston Soc. Nat. Hist., vol. XXVI, pp. 257-273; June, 1894.) The processes of fluvial deposition and subsequent erosion, leaving remnants of old flood-plains as terraces on the sides of the river valleys, are here reviewed, with consideration of the geographical cycle and development of a normal river, and a classification of alluvial terraces according to the variable conditions of their origin. In glaciated regions the abundant stream terraces of stratified gravel, sand and clay have been sculptured, and in large part redeposited again and again, from the original flood-plains supplied by the drainage of the ice-sheet during its departure at the close of the Glacial period. The Connecticut river valley, rendered classic by the early work of E. and C. H. Hitchcock for the geological surveys of Massachusetts and Vermont, and later more fully described in its northern part for the survey of New Hampshire, has along most of its course two, three, four, or more of these terraces on one or both sides of the river. Usually drift-bearing countries have undergone some differential elevation since the weight of the ice was removed, and each terrace is thought by the author to show a temporary level of the stream during a time of rest or slackening of the uplift, while the escarpments or steep fronts of the terraces are regarded as evidence of intermittent stages when the upward movement was more rapid, causing the streams to cut down their channels. W. U.

The Preglacial Channel of the Genesee river. By A. W. GRABAU. (Proceedings, Boston Soc. Nat. Hist., vol. XXVI, pp. 359-369, with map; read May 16, 1894.) The Genesee river above Portageville, N. Y., flows in a broad preglacial valley. Next the river has cut a narrow and very picturesque rock gorge for about 25 miles to Mt. Morris. Again it flows thence nearly to Rochester in a large preglacial channel; but in the city of Rochester it a second time enters a deep postglacial rock gorge, seven miles long, descending into it with three falls. Above Mt. Morris the second broad valley is occupied by the Canaseraga creek; and farther west the Oatka creek, another tributary of the Genesee, runs in a parallel preglacial valley. The connection of these valleys with their probable preglacial continuation along the Irondequoit river and bay (described in the AM. GEOLOGIST, vol. V, pages 202-207, with map, April,

1890), to the present area of lake Ontario, has not been definitely traced, because the intervening areas are heavily drift-covered.

It seems probable that some estimate of the length of the Postglacial period may be derived from the rate of recession of the Genesee falls at Rochester, as in the similar cases of the falls of Niagara and St. Anthony. Further light also on this question may be expected from measurements of the volume of the Genesee gorge above Mt. Morris, with consideration of the manner and rate of its erosion by the river. These problems may well be recommended for practice in field work by special students in geology. W. U.

The Granites of Cecil county in northeastern Maryland. By G. P. GRIMSLEY. (A thesis accepted for the degree of Doctor of Philosophy by the Johns Hopkins University, June, 1894. 50 pp., 3 pls., 1894. Published originally in the Jour. Cincinnati Soc. Nat. Hist., April and July, 1894.) This paper describes the granites of that part of the ancient crystalline area of Maryland which lies on the east bank of the Susquehanna river and just south of the Pennsylvania line. Toward the north the granite comes in contact with the gabbro of the region; here the former rock becomes more basic and in places appears to grade into the latter, but elsewhere the granite is seen to be of later date than the gabbro. The granite is separated into two areas by a belt of staurolite mica-schist; the northern (Rolandville) area exhibits striking mineralogical changes, the most prominent of which is the extensive development of epidote; the southern (Port Deposit) area shows crushing and shearing, and the rock has become a pronounced granite-gneiss. The belt of staurolite mica-schist shows a complete alteration of the staurolite to an aggregate of muscovite, chlorite, and quartz. Separation of the heavier constituents of the granite soils by use of the ordinary miner's pan, a method employed with success by Derby in Brazil and by others, brings to light a number of the less common minerals of the parent rock. U. S. G.

On the Cambrian Formation of the Eastern Salt Range. By FRITZ NOETLING. (Records of the Geological Survey of India, vol. XXVII, pt. 3, pp. 71-86, pl. i, 1894.)

That there should, to all appearances, be such a dearth of palæontologists in the United Kingdom as to compel the government to turn to the continent for men of this kind for its Indian Geological Survey, has been a matter of frequent comment and some heartburnings. The combination of stratigraphical geologist and palæontologist seems, lamentably, to be somewhat out of fashion, and the predominance of anatomical and phylogenetic palæontologists among English students may have been the principal reason why the Directorship of the Indian Survey invited professor W. Waagen, of Prague, and Dr. Fritz Noetling, of Strassburg, to undertake its palæontological work. If the English palæontologists felt at all "raw" over this, it may have given some of the more sinful of them a delicious, if slight, tingle of satisfaction when the distinguished German savant described, in the impressive tomes of the "Palæontologia Indica," a fauna composed of inarticulate brachiopods

of very primitive and distinctly Cambrian types and with stout arguments maintained its Upper Carboniferous age. It is some time since Waagen revised this opinion, with the aid of trilobites subsequently discovered in the same rocks by the English members of the survey, who had found the brachiopods and had regarded them of Silurian age.

The history of this discussion is briefly reviewed by Noetling in this paper, and the author, in the light of some additional discoveries, dissents from all of Waagen's later conclusions in regard to the Cambrian faunas. Noetling proposes the following subdivision of the Salt Range Cambrian, in descending order:

4. Bhaganwalla group, or salt-crystal pseudomorph zone;
3. Jutana group, or magnesian sandstone;
2. Khussak group, or Neobolus beds;
1. Khewra group, or purple sandstone.

The Khussak group alone contains fossils and is the oldest fossiliferous formation of the Salt Range. Noetling makes a five-fold division of it:

V. Zone of Olenellus sp., with "brachiopods belonging to the family of Trimerellidæ" (*Lakhmina ?*) and probable fragments of *Olenellus*.

IV. Zone of *Neobolus warthi*.

III. Upper annelid sandstone.

II. Zone of *Hyolithes wynnii*, with *Neobolus*? sp. and small trilobites.

I. Lower annelid sandstone, with *Hyolithes* and some "bivalves."

The position, in the series, of the trilobites which determined, for Waagen, the Cambrian age of the fauna, viz., *Conocephalites warthi* and *Olenus? indicus* W., is uncertain. It is stated by Noetling that they do not belong to the genera to which they were referred, and the two writers are at open variance in their interpretation of the faunal succession, a difference which cannot be adjusted without "another candle." Meanwhile the foreign members of Dr. King's survey are "out."

J. M. C.

On the Occurrence of Chipped (?) Flints in the Upper Miocene of Burma. By FRITZ NOETLING. (Records of the Geological Survey of India, vol. XXVII, pt. 3, pp. 101-103, pl. 1, 1894.)

The flint flakes described were found by the author himself in a ferruginous conglomerate in the Yenangyoung oil-field, containing remains of *Rhinoceros* and *Hippotherium*. The flakes figured certainly suggest human workmanship, and as to their nature the author says: "I do not want to express an opinion; all I can say is, that if flints of this shape can be produced by natural causes, a good many chipped flints hitherto considered as undoubtedly artificial products are open to grave doubt as to their origin." J. M. C.

Cone-in-Cone: how it occurs in the Devonian series in Pennsylvania, with further details of its structure, varieties, etc. By W. S. GRESLEY. (Quart. Jour. Geol. Soc., London, vol. 50, pp. 731-739, with plates XXXV and XXXVI, Nov. 1st, 1894.) In the Portage beds of northwestern Pennsylvania the cone-in-cone structure is shown to be a product of alteration. It occurs,

as previously observed, along a very persistent horizon, known as the Ferriferous limestone, usually several feet thick, but occasionally thinning down to four inches or less, and in these thin and shaly portions the cone-in-cone formation is conspicuously developed. Several hundred feet lower in the series the author has found typical cone-in-cone at numerous horizons of interbedded thin sandstones and shales. The cone-in-cone occupies parts of the shaly layers, and is distinctly calcareous, differing in this respect from the contiguous strata, so that this peculiar structure appears to be due to concretionary action, under pressure, gathering the carbonate of lime and partially expelling the clayey matter. Elsewhere the calcareous matter has been sometimes replaced by hematite, limonite, pyrites, marcasite. and ferruginous quartz.

W. U.

RECENT PUBLICATIONS.

1. *Government and State Reports.*

Smithsonian Report, 1893. contains: The ice age and its work, A. R. Wallace; Geologic time as indicated by the sedimentary rocks of North America, C. D. Walcott; The age of the earth, Clarence King; Deep-sea deposits, A. Daubrée.

Thirteenth Ann. Rept., U. S. Geol. Survey. Part I, Report of the Director, J. W. Powell. Part II, Geology, contains: Second expedition to Mount St. Elias, I. C. Russell; The geological history of harbors, N. S. Shaler; The mechanics of Appalachian structure, Bailey Willis; The average elevation of the United States, Henry Gannett; The Rensselaer grit plateau of New York, T. N. Dale; The American Tertiary Aphidæ, S. H. Scudder. Part III, Irrigation.

U. S. Geol. Survey, Monograph XIX, The Penokee iron-bearing series in Michigan and Wisconsin, by R. D. Irving and C. R. Van Hise. Pp. i-xix, 1-534, 37 pls., 1892.

U. S. Geol Survey, Monograph XXI, Tertiary rhynchophorous Coleoptera of the United States, by S. H. Scudder. Pp. i-xi, 1-206, 12 pls., 1893.

U. S. Geol. Survey, Monograph XXII, A manual of topographic methods, by Henry Gannett. Pp. i-xiv, 1-300, 18 pls., 1893.

Bulletins, U. S. Geol. Survey: No. 97, The Mesozoic Echinodermata of the United States, W. B. Clark; No. 98, Flora of the outlying Carboniferous basins of southwestern Missouri, David White; No. 99, Record of North American geology for 1891, N. H. Darton; No. 100, Bibliography and index of the publications of the U. S. Geological Survey, 1879-1892, P. C. Warman; No. 101, Insect fauna of the Rhode Island coal field, S. H. Scudder; No. 102, A catalogue and bibliography of the North American Mesozoic Invertebrata, C. B. Boyle; No. 103, High temperature work in igneous fusion and ebullition, chiefly in relation to pres-

sure, Carl Barus; No. 104, Glaciation of the Yellowstone valley north of the Park, W. H. Weed; No. 105, The Laramie and the overlying Livingston formation in Montana, W. H. Weed; No. 106, The Colorado formation and its invertebrate fauna, T. W. Stanton; No. 107, The trap dikes of the Lake Champlain region, J. F. Kemp and V. F. Marsters; No. 108, A geological reconnoissance in central Washington, I. C. Russell; No. 109, The eruptive and sedimentary rocks on Pigeon point, Minnesota, W. S. Bayley; No. 110, The Paleozoic section in the vicinity of Three Forks, Montana, A. C. Peale; No, 111, Geology of the Big Stone Gap coal field of Virginia and Kentucky, M. R. Campbell; No. 112, Earthquakes in California in 1892, C. D. Perrine; No, 113, A report of work done in the division of chemistry during the fiscal years 1891-'92 and 1892-'93, F. W. Clarke; No. 114, Earthquakes in California in 1893, C. D. Perrine; No. 115, A geographic dictionary of Rhode Island, Henry Gannett; No. 116, A geographic dictionary of Massachusetts, Henry Gannet; No. 117, A geographic dictionary of Connecticut, Henry Gannet.

Ann. Rept. Geol. Survey of Arkansas, for 1891, Vol. II, 1894, contains: The geology of Benton county, F. W. Simonds and T. C. Hopkins; Elevations in the state of Arkansas, J. C. Branner; Observations on erosion above Little Rock, J. C. Branner; Magnetic observations, J. C. Branner; The Mollusca of Arkansas, F. A. Sampson; The Myriapoda of Arkansas, C. H. Bollman; The fishes of Arkansas, S. E. Meek; The geology of Dallas county, C. E. Siebenthal; Bibliography of the geology of Arkansas, J. C. Branner.

Ann. Rep., Geol. Survey of Arkansas, for 1892, Vol. II, 1894, contains: The Tertiary geology of southern Arkansas, G. D. Harris.

California State Mining Bureau, Bull. No. 3, The gas and petroleum-yielding formations of the central valley of California, by W. L. Watts. 100 pp., 1894.

Missouri Geol. Survey, Sheet No. 2, the Bevier sheet, with a report on the same. Pp. i-ix, 1-75., Oct., 1893.

Missouri Geol. Survey, Sheet No. 3, The Iron Mountain sheet, with a report on the same. Pp. i-ix, 1-85, 5 pls., Jan., 1894.

Bulletin No. 4, Illinois State Museum of Nat. Hist.: Upper Devonian and Niagara Crinoids, by S. A. Miller and W. F. E. Gurley. 37 pp., 3 pls., Oct. 15, 1894.

II. Proceedings of Scientific Societies.

Congrès Géologique International, Compte Rendu de la 5me Session, Washington, 1891 (published 1893, edited by S. F. Emmons) contains: Historique du congrès; Procès-verbeaux des séances du congrès; Compte-rendu des séances du congrès, including Communications sur la corrélation des roches (La corrélation par plantes fossiles, L. F. Ward. The pre-Cambrian rocks of North America, C. R. Van Hise). Compte-rendu de la discussion sur la corrélation des roches, Compte-rendu de la discus-cussion sur la classifications des dépôts pléistocène, Compte-rendu de la discussion sur les gammes de coloriage générales, Compte-rendu des ex-

cursions, Explication des excursions, including La géologie des environs de Washington, Excursion aux Montagnes Rocheuses, Excursion au Lac Supérior.

Trans. N. Y. Acad. of Sciences, vol. 13, contains: Observations on the geology and botany of Martha's Vineyard, Arthur Hollick; The ore deposits at Franklin Furnace and Ogdensburg, N. J., J. F. Kemp: Additional notes on recently discovered deposits of diatomaceous earth in the Adirondacks, C. F. Cox; On allanite crystals from Franklin Furnace, N. J., A. S. Eakle: A Pleistocene lake bed at Elizabethtown, Essex Co., N. Y., Heinrich Ries; A new Cladodont from the Ohio Waverly, Cladoselache newberryi, n. sp., Bashford Dean; Some further notes on the geology of the north shore of Long Island, Arthur Hollick: An orbicular granite from Quonochontogue beach, R. I., J. F. Kemp; Mineralogical notes—topaz from near Palestine, Texas, and Diamonds from Wisconsin, G. F. Kunz; On some new forms of wollastonite from New York state, Heinrich Ries; Note on the petrography of certain basaltic boulders from Thetford, Vt., E. O. Hovey; Microscopic organisms in the clays of New York state, Heinrich Ries; On caswellite, an altered biotite from Franklin Furnace, N. J., and quartz crystals from Ellenville, N. Y., A. H. Chester; The intrusive rocks near St. John, N. B., W. D. Matthew; Additional note on wollastonite from New York state, Heinrich Ries; A group of diabase dikes among the Thousand islands, St. Lawrence river, C. H. Smyth, Jr.; The geology of Essex and Willsboro' townships, Essex Co., N. Y., T. H. White.

Proc. California Acad. of Sciences, sec. ser., vol. 4, pt. 1, contains: On some Pliocene fresh-water fossils of California, J. G. Cooper.

Proc. A. A. A. S., vol. 42, Madison meeting, contains; Geologic time as indicated by the sedimentary rocks of North America, C. D. Walcott; and abstracts of several papers, most of which have been published elsewhere in full.

CORRESPONDENCE.

Note on "Nanno." The description of this remarkable type of cephalopod, by J. M. Clarke, in the October American Geologist, from the Trenton limestone of Minnesota, has interested me very much, since formerly I collected specimens of the same species near Minneapolis. This type of cephalopod is not new, however, having been previously found by Gerhard Holm, who in 1885 described and figured *Endoceras belemnitiforme*, a very similar species, from the Silurian of the island of Oeland and of Estland [Esthonia]. (See Holm, "Ueber die innere Organisation einiger silurischer Cephalopoden," in Palæontologische Abhandlungen, von W. Dames und E. Kayser, vol. 3, pt. 1, p. 4, and plate I). [*]

[*The final paper by Prof. Clarke, as contributed to the reports of the Minnesota Geological Survey, now in press, refers fully to the work of Holm, and states that, notwithstanding his reference of this form to Endoceras, it is quite different and worthy of a generic rank.—Eds.]

Endoceras belemnitiforme Holm presents the same generic characters as *Nanno aulema* Clarke. In the belemnite-like specimens (Holm, loc. cit., pl. I, figs. 5a-5c, and Clarke, loc. cit., pl. VI, figs. 5-7) the apical cone represents, according to Holm, the initial chamber of the *Endoceras*; the contracted surface, the first septum; and the elongated portion, the siphuncle. The thickened wall or "apical solid cone," as described by Clarke, is noted also by Holm in *E. belemnitiforme* (loc. cit., p. 8. pl. I, fig. 2); and that the sipho is also in contact with the outer shell, and even fastened to the same, is both described and figured.

Very interesting is the interpretation made by Holm of this species of *Endoceras*, the only species of which the initial chamber was known, and in the structure of which he finds the suggestion that the initial chamber and the sipho of *Endoceras* species with large siphos served at first, and to a great extent continually, as a visceral chamber. From the characters presented by this species, Holm thinks that the *Endoceras* type is the primitive fossil cephalopod, and that the Tetrabranchiata were yet earlier derived from forms having an open conical shell without septa or sipho. The striking similarity between *E. belemnitiforme* and *Nanno aulema* permits exactly the same interpretation from either.

The "siphonal cone," as composed of siphonal sheaths described by Clarke, is, on the other hand, not observed by Holm; but, according to Holm's interpretation, it might be expected that the shell at the apex would be continually thickened while the initial chamber and sipho were still occupied by the viscera. The existence of such a structure seems to support the theory given by Holm,* that the primitive Tetra branchiata filled the entire conical shell; that afterward, following extended growth of the shell and elongation of the animal, an air chamber enclosed by a septum was formed upon one side of the animal: and that by the formation of a succession of similar septa originated the elongated sipho. This, which was occupied by part of the viscera at first, as in some species of *Endoceras*, has, in the cephalopods with small siphons, been reduced to a narrow, perhaps functionless structure.

The name *Nanno*, which is seemingly an inappropriate one for a genus of Cephalopoda, is, according to other authors, only a synonym for *Endoceras*; but the new species described is of great interest.

FREDERICK W. SARDESON.

Geologisch-mineralogisches Institut der Universität, Freiburg i. Baden, Oct 20, 1894.

EVIDENCE OF SUPERGLACIAL ESKERS IN ILLINOIS AND NORTHWARD. The paper by Mr. J. B. Woodworth on the origin of eskers, noticed on page 396, and the work of Mr. G. H. Barton on the same question, also there cited, with the discussion of superglacial drift by Prof. R. D. Salisbury in the last number of the Journal of Geology (vol. II, pp. 613-632, Sept.-Oct., 1894), make this an opportune time for directing atten-

*See also Steinmann and Döderlein, "Elemente der Paläontologie" (1890), p. 349.

tion to the evidences of the formation of the eskers which have been studied in Illinois, Iowa, Minnesota, and Manitoba, by superglacial streams.

Where eskers (osars) have been explored by Mr. Leverett in Illinois and adjacent states, they are found, as described by Prof. Chamberlin in the Journal of Geology (vol. I, pp. 266, 267, April-May, 1893), to vary in length from a few miles to about fifty miles, and to lie often as narrow gravel and sand ridges in wide river-like channels cut into the general sheet of till, but to have ascents and descents over present watersheds. It is thus seen that these eskers were deposited by ice-walled streams, either subglacial, englacial, or superglacial. While Prof. Chamberlin, in the paper cited, regards them as probably subglacial, a different explanation seems to accord with their superglacial formation. From the steep slopes adjoining river valleys or cañons cut into the waning ice-sheet, its englacial and finally superglacial drift, exposed by ablation when the greater part of the thickness of the ice there had been melted away, would slide down, or be washed down by rains and rivulets, into the stream bed, to contribute partly to the esker and to be partly carried onward by the stream. When the ice wholly disappeared, a wide shallow trough in the till and the esker ridge would have the relationship described.

In Iowa the prominent paha or loess eskers described by McGee (U. S. Geol. Survey, Eleventh An. Rep., for 1889-'90, pp. 435-471) are attributed chiefly to superglacial drainage, deriving the material of the paha from drift exposed by ablation on the ice surface.

In Minnesota eskers are rather infrequent. The most notable are in Bridgewater and Lake Johanna townships. The former is an esker series about seven miles long, mapped by Prof. N. H. Winchell, who shows its origin to have been by a superglacial stream (Geology of Minn., vol. I, 1884, pp. 665-669); and the latter series consists of several parallel ridges, mapped by the present writer and similarly explained (vol. II, 1888, pp. 489, 490).

The most conclusive evidence of the origin of the material of eskers from superglacial drift I find in the esker called Bird's hill, at the station of this name on the Canadian Pacific railway in Manitoba, seven miles northeast of Winnipeg. This esker had such relationship to the glacial lake Agassiz, there 500 feet deep as soon as the ice-sheet retreated, that its material is shown to have come from a somewhat greater hight in the lower part of the ice-sheet, which attained probably a maximum thickness of 5,000 feet or more above that region, if we may judge from its known thickness upon New England and New York, covering Mt. Washington and the Green and Adirondack mountains. It is further learned, by a mass of till fallen into the esker gravel and sand, that several feet of englacial drift existed there above the altitude of 500 feet in the ice. (Geol. Survey of Canada, An. Rep., new series, vol. IV, for 1888-'89, pp. 38-40 E.)

The observations of the eskers of Bird's hill and the Pinnacle hills at Rochester, N. Y. (Proc., Rochester Acad. of Science, vol. II, pp. 181-200,

Jan., 1893), with my other and earlier studies of eskers in New Hampshire and other parts of New England and in Long Island, convince me that these remarkable ridges of modified drift were, in all the areas which I have studied, derived chiefly from englacial drift which had become superglacial, as on the Malaspina ice-sheet in Alaska, and that they were deposited in the cañon-like lower courses of superglacial rivers. This indicates that the englacial drift, as shown by articles in the AM. GEOLOGIST for December, 1891, and December, 1892, and July, 1893, was of considerable amount in the lower part, perhaps for a fourth of the whole thickness, of the ice-sheet. WARREN UPHAM.

Nov. 20th, 1894.

AN EARLY OBSERVATION BEARING ON THE HISTORY OF THE GREAT LAKES. The reading of Dr. J. W. Spencer's "Review of the History of the Great Lakes," in the AMERICAN GEOLOGIST for November, recalled an observation made in the last century by Alexander Henry. He was an English fur-trader, and in carrying on his business with the Indians journeyed from Montreal to Michilimackinac in 1761. The route taken was the Ottawa and Mattawa rivers, lake Nipissing and its outlet, French river, to Georgian bay and lake Huron. An account of his travels was published in 1809. The following extract from it shows that he recognized the former presence of waters at a different level along what is now regarded as for a time an outlet of the three upper lakes:

"Leaving the Indians, we proceeded to the mouth of the lake [Nipissing] at which is the carrying-place of La Chaudière Française, a name part of which it has obtained from the holes in the rock over which we passed; and which holes, being of the kind which is known to be formed by water, with the assistance of pebbles, demonstrate that it has not always been dry, as at present it is; but the phenomenon is not peculiar to this spot, the same being observable at almost every carrying-place on the Outaouais [Ottawa]. At the hight of a hundred feet above the river, I commonly found pebbles, worn into a round form, like those upon the beach below. Everywhere the water appears to have subsided from its ancient levels; and imagination may anticipate an era at which even the banks of Newfoundland will be left bare."* E. J. HILL.

Chicago, Nov. 24, 1894.

PERSONAL AND SCIENTIFIC NEWS.

THE GEOLOGICAL SOCIETY OF AMERICA will meet at Baltimore Thursday, Dec. 27, the assembly being in the geological laboratory of Johns Hopkins University. It is expected that Pres. D. C. Gilman will welcome the society, and that Prof. W. B. Clark will read a memorial of Dr. George H. Williams.

*Travels and Adventures in Canada and the Indian Territories, between the years 1761 and 1776. By Alexander Henry, Esq. New York, 1809. p. 31.

Mr. E. H. LONSDALE, recently of the Iowa Geological Survey, has resigned to accept a position on the Missouri survey.

Mr. C. D. WALCOTT, director of the U. S. Geological Survey, has recently made a western tour to inspect its work.

Prof. S. F. EMMONS is to have general charge of the work of the U. S. Geol. Survey in the Rocky mountains region.

Prof. G. F. BECKER, who has made a reconnaissance of the southern Appalachian gold-fields during the past summer, will specially examine, with Mr. H. B. C. Nitze of the North Carolina Geological Survey, the principal mines in the central southern part of that state.

WILLIAM TOPLEY, F. R. S., long engaged on the Geological Survey of England, died Sept. 30th.

A SPECIES OF *Oldhamia*, closely related to *O. antiqua* of the Cambrian rocks in Ireland, has been collected by T. Nelson Dale at several localities in a belt of reddish shales west of the Renssalaer plateau, near Troy, N. Y. It is described by C. D. Walcott under the name *Oldhamia* (*Murchisonites*) *occidens*, in the Proc. Nat. Museum, vol. XVII, pp. 313-315, 1894; and the formation is regarded as of Upper Cambrian or Lower Ordovician age.

THE GEOLOGY OF DENVER AND ITS VICINITY is well summarized in a popular address, of 36 pages, by George L. Cannon, Jr., as the retiring president of the Colorado Scientific Society. A very remarkable epoch of erosion is shown to have marked the transition from the Tertiary to the Quaternary era, removing 1,000 to 1,500 feet of horizontal strata from the site of the city of Denver, followed by an epoch of deposition of river drift and loess.

THE NEW SCIENCE REVIEW is a recently launched quarterly devoted to the discussion of scientific theories and discoveries. It does not address itself to the specialist, but to the intelligent public at large, and endeavors to present the results of recent work and thought in the various lines of natural and physical science. Two numbers have already been issued. It is conducted by J. M. Stoddart, and is published by the Transatlantic Publishing Co., New York (63 Fifth Ave.) and London.

AROUND THE WORLD fills a nook in monthly journalism which was before entirely neglected. It is devoted to geography, travels, and science. It is not ponderous like Harper's, nor prosaic like the Popular Science Monthly, nor radical like the Arena. It is highly instructive and lightly scientific without dilettanteism. Its pages are scrupulously edited and faultlessly printed, while its elegant illustrations are so profuse that from the first page to the last it is a gallery of portraits of nature all of which deserve to be bound together and preserved.

AMERICAN CRINOIDS. The first hundred pages of Wachsmuth and Springer's long expected monograph on American crinoids have left the press. The work has developed greatly since first planned and has prolonged the time of its appearance much beyond the date originally set. The camarate crinoids which form the part now being issued are comprised in two large quarto volumes, one of text containing over 600 pages, and the other of plates nearly 100 in number. The latter have been beautifully reproduced by the best of modern processes. The work is issued by the Museum of Comparative Zoology of Cambridge; and the edition is limited to 750 copies. It embodies the results of what is doubtless the finest piece of paleontological investigation ever undertaken in this country; and it may be regarded as a model of modern methods. It is the outcome of thirty-five years constant and untiring effort; these two volumes constitute the first half of the entire work. When completed it will form one of those works which will be the standard of reference for a century to come.

THE STANFORD UNIVERSITY has recently obtained a cast of a vertebral column and ribs found fossil in a marine shaly sandstone formation of Miocene age, at an altitude of 1,400 feet above the sea, near Roblar, California. The resemblance to man is very remarkable, but Pres. D. S. Jordan, of the university, thinks that more probably it was some species of sloth. Prof. J. P. Smith states that it might be readily pronounced a fossil man, if the rock formation were recent. "To be sure," he remarks, "a river might have brought the dead man, sloth, or whatever it was, to the ocean, and the currents might have carried it out, but it certainly seems more reasonable to suppose some aquatic creature left its imprint there."
-*San Francisco Examiner, Nov. 4, 1894.*

THE GLACIAL GEOLOGY OF MT. KENYA in eastern Africa, situated on the equator, about 150 miles east of the lake Victoria Nyanza, is described by Dr. J. W. Gregory in the Quarterly Journal of the Geological Society of London (vol. 50, pp. 515-530, Nov. 1st, 1894). The mountain attains a hight of about 19,500 feet and covers an area of about 700 square miles. The existing glaciers, one of which is named in memory of the late Prof. Henry Carvill Lewis, descend to the altitude of 15,300 feet. Former glaciation, at so recent a time that the striation of boulders and of the bed rock is retained wherever it has been protected by a covering of soil, reached 5,500 feet lower, or to 9,800 feet above the sea. Lake basins, moraines, rounded rock surfaces, and glacial striæ, attest the former envelopment of the whole upper part of Mt. Kenya by an ice-cap, of which the present glaciers are puny remnants. The cause of the

former great extent of the glaciers is thought by Dr. Gregory to have been a greater altitude of the country including this mountain; and he thinks that this epeirogenic uplift may have extended westward across Africa to the Cameroons mountains and to the mouth of the Congo river, which has a submerged continuation of its valley to the depth of 6,000 feet beneath the sea level. The alpine flora found on the mountains of Abyssinia, on Kenya, Kilima Njaro, and the Cameroons, furnishes additional evidence that during a late geologic epoch this extensive continental area was a much higher plateau than now, having consequently a cooler and moister climate, with a continuous flora similar to that which now survives only upon the mountains.

NATIONAL ACADEMY OF SCIENCES. The following papers were read at the Autumn meeting, Oct. 30, 31 and Nov. 1, 1894, at New Haven: An indirect experimental Determination of the Energy of Obscure Heat, William A. Rogers; Determination of the Errors of the Circles of an electrotype copy of Tycho Brahe's Altitude Azimuth instrument now in possession of the Smithsonian Institution, William A. Rogers; The Winnebago County, Iowa, Meteorites, and the Meteor, Hubert A. Newton; Literal Expression for the Motion of the Moon's Perigee, George W. Hill; Atmospheric Dust and Aqueous Precipitation in Arctic Regions, William H. Brewer; Further Researches on the Polar Motion, Seth C. Chandler; The Relation of Gravity to Continental Elevation, Thomas C. Mendenhall; The Legal Units of Electrical Measure, Thomas C. Mendenhall; On derived Equations in Optics, Charles S. Hastings; On a method of eliminating Secondary Disperson, using ordinary silicate Glasses only, Charles S. Hastings; The Chemical Nature of Diastase, Thomas B. Osborne; Some Features in the Development of Brachiopods, Charles E. Beecher; On the Presence of Devonian Fossils in Strata of Carboniferous Age, Henry S. Williams; On the influence of Insolation upon Culture Media, and of Desiccation upon the Vitality of the Bacillus of Typhoid, of the Colon Bacillus, and of the Staphylococcus aureus, John S. Billings; Report on Photographing Meteors, William L. Elkin; Biographical Memoir of F. V. Hayden, Charles A. White; Geographical and Bathymetrical Distribution of the Deep Sea Echinoderms, discovered off the American Coast, north of Cape Hatteras, A E. Verrill; On the effect of Pressure in broadening Spectral Lines, A. A. Michelson; Remarks upon the progress of work upon a Handbook of the Brachiopoda, James Hall; Note upon the Occurrence and Distribution of the Dictyospongidæ in the Devonian and Carboniferous Formations, James Hall; Infra-red Spectrum, S. P. Langley; On a certain Theorem in Theoretical Mechanics, J. W. Gibbs.

INDEX TO VOL. XIV.

MBER, 1894. VOL. XIV, NO. 6.

THE AMERICAN GEOLOGIST

A MONTHLY JOURNAL OF

GEOLOGY AND ALLIED SCIENCES.

CONTENTS.

The American Antiquarian
AND
Oriental Journal.

PUBLISHED AT 175 WABASH AVENUE, CHICAGO, ILL.

Edited by STEPHEN D. PEET, Good Hope, Ill.

Bi-Monthly. Price, $4.00 Per Year.

The First Magazine Devoted to Archæology and Ethnology Established in America.

There has been no time in all the sixteen years, during which the magazine has continued, when the volume promised so well as that for 1895. This volume will take a broader scope and will report explorations and discoveries in different countries.

The following gentlemen will act as Associate Editors:

REV. W. C. WINSLOW, D. D., LL. D., Explorations in Egypt.
PROF. T. F. WRIGHT, Explorations in Palestine.
HENRY W. HAYNES, Explorations in Europe and Paleolithics.
DR. A. S. GATSCHET, Indian Linguistics.
MARSHALL H. SAVILLE, Central America and the Maya Hieroglyphics.
HON. JAMES WICKERSHAM, Northwest Coast, Eastern Asia, and Polynesia.

The Contributors for 1894 are as follows:

Dr D. G. BRINTON,	M. JAMES DEANS,	Prof. A. F. CHAMBERLAIN,
G. O. DORSEY,	Dr. J. WALTER FEWKES,	Dr. WM. WALLACE TOOKER,
H. C. MERCER,	Mrs. ZELIA NUTALL,	Rev. WM. M. BEAUCHAMP,
C. STANILAND WAKE,	Dr. CYRUS THOMAS,	

BEST CHILDREN'S MAGAZINE.

A monthly visitor to the little ones, having charming stories by celebrated authors, beautiful pictures and poems, is **OUR LITTLE ONES and THE NURSERY.** Hailed with delight and happiness by the little ones Its merits need no explanation. Stories are carefully chosen, and seek to interest and develop the observation power. The illustrations are bright, effective and decidedly artistic. Looked forward to with eager anticipation in the nursery. Get a copy.

27th Year. $1.50 a Year. New Volume Just Commenced. Sample Copy for two-cent Stamp.

Russell Pub. Co., 196 Summer St., Boston, Mass.

Rates for Excerpts from the Geologist.

As the Publishers of the GEOLOGIST do not furnish extras to the contributors, we will furnish them at the following rates:

	2 Pages.	4 Pgs.	6 Pgs.	8 Pgs.	10 Pgs.	12 Pgs.	14 Pgs.	16 Pgs.
25 Copies,	$1.00	$1.60	$2.25	$2.50	$2.75	$3.25	$3.75	$4.25
50 "	1.10	2.00	2.50	2.75	3.25	3.75	4.25	5.00
100 "	1.25	2.50	3.00	8.25	3.75	4.50	4.75	5.50
200 "	1.50	3.00	3.50	3.75	4.50	5.25	5.75	6.50

One page will be charged same price as two pages, and three pages same as four, and so on. Covers will cost 50 cents for the first 12—all over 12 will be 1 cent each up to 100. If 100 or more covers are ordered, the lot will be at the rate of 1 cent each. We do not pay transportation charges, but will send them the cheapest way; either by mail or express. Extras will be printed on the same paper as the GEOLOGIST. Covers of extras will carry a brief announcement of the GEOLOGIST.

ALFRED ROPER PRINTING CO., Book and Job Printers,
417 Hennepin Ave., Minneapolis, Minn.